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Astronomy in Our Schools
Small Scope Fix-Ups

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The Changing Face of Copernicus Crater

Meade® Wide-Field f/6.3 SCT's:

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f/6.3 SCHMIDT-CASSEGR
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Mode
Set
RA 23.58
DEC -35.6
N
W
E
S
∞ Focus Near
2X
8X
Map
Quartz
Manual
Solar
Sidereal
Lunar
Reticle Adjust
U.S.A.
MEADE
MICROPROCESSOR CONTROLLED
LX QUARTZ PULSE DRIVE
Current (mA x 1000)
N S
On Off
Dec Motor
Electric Focus
Reticle
Command Center
Power 12V.D.C.
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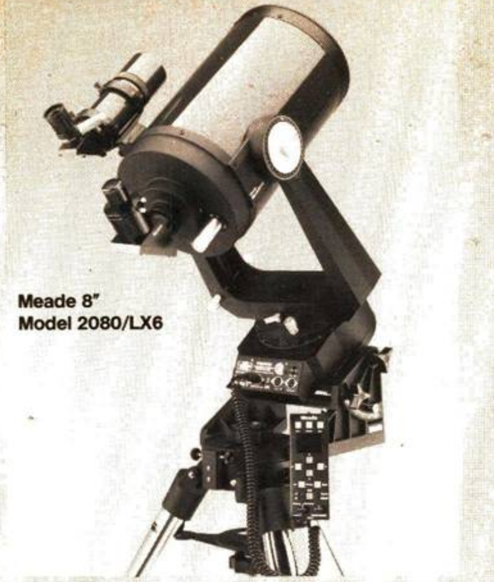
Encoders

The LX6 Revolution Is Here.

For the First Time Ever — Wide-Field Schmidt-Cassegrain Telescopes that Yield a 60% Reduction in Photo Exposure Times!

New Meade 8″ and 10″ LX6 Wide-Field Schmidt-Cassegrains combine the wide fields of view, fast photo exposure times, and high-contrast imaging long sought by the serious amateur. Consider this listing of *standard* LX6 features:



Meade 8″ Model 2080/LX6

1 Fast f/6.3 Schmidt-Cassegrain Optics — *Optics that yield photographic and visual performance impossible to achieve with the f/10 optics that are standard on all other SC telescopes. Eyepiece for eyepiece, obtain:*

☐ A field of view that is **59%** wider than with f/10 Schmidt-Cassegrains. Use the Meade Super Wide Angle 40mm eyepiece on the 8″ LX6 to obtain a true field over *2 degrees* in diameter!

☐ Images both visually and photographically that are **2 ½ times** brighter than with an f/10 system.

☐ A **60%** reduction in astrophoto exposure times: 30 minute exposures become 12 minute exposures. Used with modern fast films, a **5-minute** color exposure of the Orion Nebula (M42) taken with the 10″ Model 2120/LX6 *yields virtually all of the nebular detail that is theoretically possible to obtain with a 10″ telescope!* With the optional Meade **Telecompressor Lens**, for an effective focal ratio of f/3.15, this exposure time is reduced still further to about **3 minutes** — an unheard of exposure time for a photovisual telescope of 10″ aperture, an exposure time that means *anyone* with an absolute minimum of experience can take magnificent deep-space astrophotos!

2 Ultra High Contrast Baffling — In addition to their superlative wide-field deep-space performance, Meade 8″ and 10″ LX6 models, because of their computer-optimized internal light baffles, yield uncompromised, high-contrast lunar and planetary images. Add the Meade 3-element **#140 2X Telenegative Barlow Lens** to obtain high-power lunar and planetary images at f/12.6.

3 Built-In Digital Readout Capability — One of the most important optional features ever made available on a Schmidt-Cassegrain: now you can find faint objects in seconds, not minutes. The LX6 Digital Readouts, located on the hand controller display, permit continuous monitoring of: *(a) telescope position in RA and Dec; (b) Local Time; (c) Sidereal Time; (d) a Digital Timer for photo exposures; and (e) Frequency readout of the pulse motor's input current* — a feature that enables extremely precise digital settings of the telescope's drive rate, readable to within ±.01 Hz. The observer simply depresses the "Mode" button on the hand controller to read out the listed data sequentially.

The Digital Readout package can be internally added easily and rapidly to the hand controller of your LX6, either at the time of purchase or at any future date, and is available at only modest additional cost.

4 New Multi-Function Electronic Command Center — The ECC hand controller, included as standard equipment, puts virtually every telescope function at your fingertips:

☐ *2X Drive Correction Speed* for precise electronic corrections during astrophotography.

☐ *8X Scanning Speed* for rapid electronic centering of the image in the field, or for roving about a specific sky region at 8 times the sidereal speed. Add the optional Declination motor for full dual-axis capability at 2X or 8X speeds.

☐ *Optional Digital Readouts*, described above.

☐ *Plus 6 other functions* that make Meade LX6's the only state-of-the-art Schmidt-Cassegrains available.

5 Quartz Microprocessor-Controlled Electronic and Drive Systems — The heart of every LX6 electronic system is a dedicated microprocessor that continuously controls, with quartz precision, all important electronic operations of the telescope, from the drive-rate frequency input to the main RA pulse motor, to the Electronic Command Center's multi-function digital readouts.

Augmented by the microprocessor, the RA pulse motor and LX worm gear system achieve true sidereal-rate tracking within ±.005% of the sidereal frequency, and with greater reliability than ever before. Switch to the "Manual" mode for variable Solar, Lunar, or Planetary tracking rates.

6 Advanced-Design Power Panel — Virtually every modern electronic accessory you might wish to add to your LX6 can be plugged-in directly to the telescope's power panel — accessories including the Meade **CAT Computer Aided Telescope** system *(see our other ad in this issue)*, with its library of more than 8000 astronomical objects; **Digital Readouts**, readable on the LX6 hand controller *(see above)*; **#1200A Electric Focuser**, for ultraprecise microfocusing; **12mm Illuminated Reticle Eyepiece**, for guiding during astrophotography; and the **Declination Motor**, for 2X/8X dual-axis operation.

In addition, the LX6 power panel includes an **Ammeter**, which continuously displays electric current usage, to gauge battery life during power cell operation; a **North-South Switch**, permitting your LX6 to be used anywhere in the world — simply flip the N-S switch to reverse drive direction for use in the Southern hemisphere; and **12-volts DC Power Inlet**. Each LX6 includes power cords for *3 types* of field operation: Directly from auto cigarette lighter plugs; directly from 115v. AC home outlets; and from the Battery Pack, included, using AA-size batteries supplied by the user.

7 Plus all of the features you expect on a top-of-the-line Meade Schmidt-Cassegrain — *Standard* features that include a **Super Plössl 26mm eyepiece** for exquisite definition and resolution across the entire visual field; 1/10-wave flat, multi-coated **2″ Diagonal Mirror** with eyepiece holders for both 1¼″ and 2″ eyepieces; **9 x 60mm Polar Illuminated Viewfinder**, the largest finder available on a commercial SCT; **Multi-Coated Optics Group**, with multi coatings on all lens and mirror surfaces for maximum light transmission and image brightness; **Equatorial Wedge**, with magnetic compass, latitude scale, bubble level, and micrometric azimuth control; and **Variable-Height Field Tripod**, the most stable in the industry.

Priced only slightly higher than conventional f/10 Schmidt-Cassegrains, Meade 8″ and 10″ LX6 models achieve photographic and visual performance levels unobtainable with any competing telescopes.

Call or visit your Meade dealer now for further details and prompt delivery of the Meade 8″ Model 2080/LX6 or 10″ Model 2120/LX6 — from the World's leading manufacturer of Schmidt-Cassegrain telescopes.

Bulletin LX6 — Available at no charge, includes complete technical specifications, descriptions, and applications, with astrophotos, of Meade LX6 models.

Complete Catalog Package #88C — $3.00 — Includes catalogs and bulletins on the entire range of Meade astronomical telescopes, Series 4000 eyepieces, and accessories.

Dealer Locations and Assistance — For your nearest Meade dealer location, or for free telescope information and assistance, call Meade Instruments toll-free from anywhere in the continental U.S.A. (except California): **1-800-854-7485**. From all other areas, including California, call direct (714) 556-2291.

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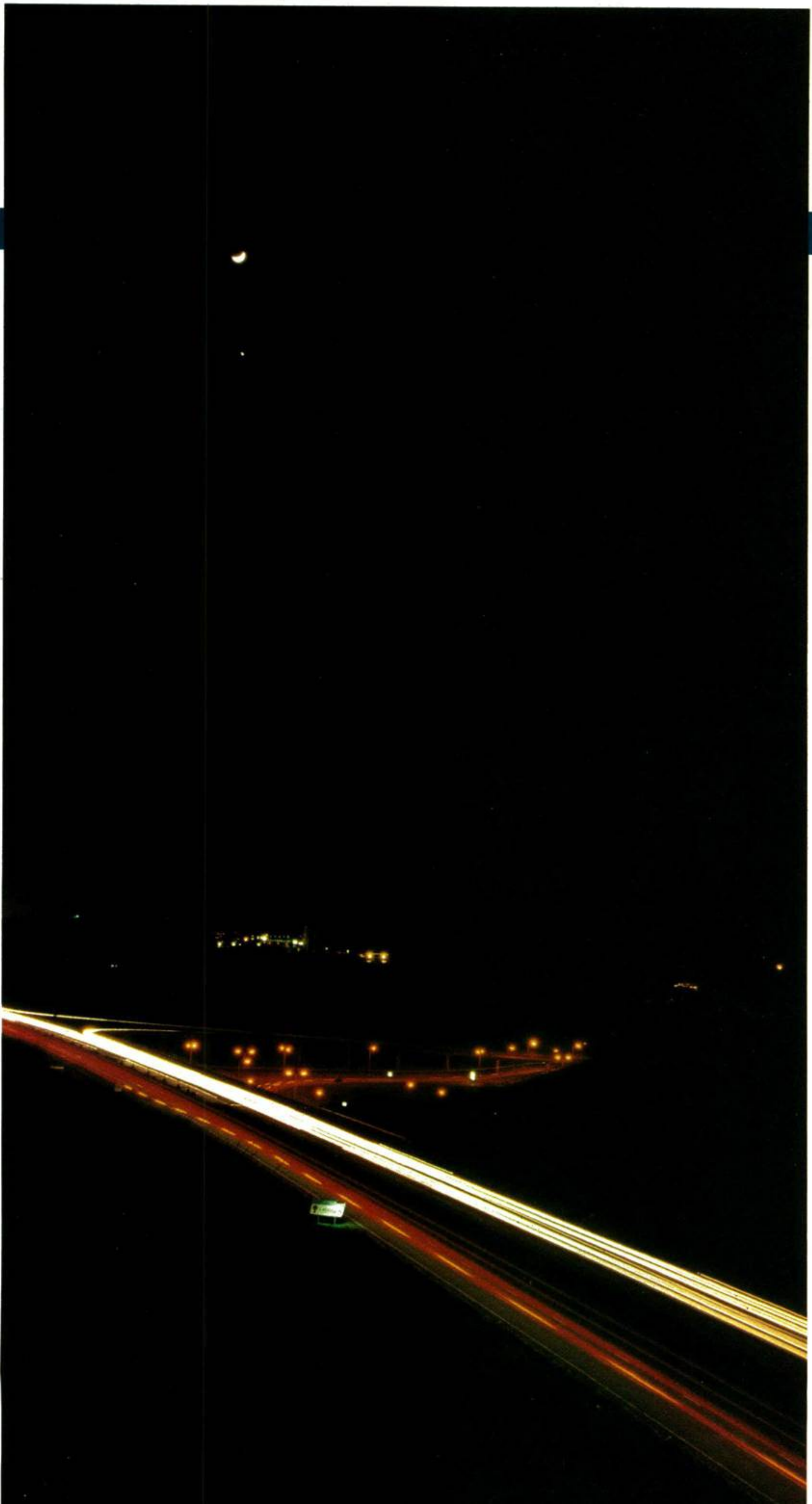
ON THE COVER:
Sixty miles wide and two miles deep, Copernicus invites every telescope user to explore its magnificent terrain (see page 70).



WHILE TRAFFIC ZIPS heedlessly by, the crescent Moon, Venus, and Jupiter (center) posed for a picture in the evening sky last March over West Sussex, England.

ASTRONOMY®

September 1988 Vol. 16, No. 9

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ABC

Behind the Scenes

IT'S GOOD FOR YOU TOO!

"You'd better eat your spinach. It's *good* for you!" Ugh. How many times have you told your kids — or been told by your parents — to try something "good" for you? That's where astronomy education stands today. "Here — try putting a little astronomy in your science curriculum. It's *good* for you."

But astronomy has a lot more going for it than spinach does. Once they try it, most people like astronomy. Kids love it. Astronomy expands their horizons, teaches them to ask questions, and shifts their thinking to new and exciting viewpoints. Astronomy incorporates all of the sciences, all branches of knowledge. Best of all, astronomy is stimulating.

You don't believe it? Try this experiment on yourself. After reading "The ABCs of Astronomy Education," read "The Difficult Births of Sunlike Stars." Of course you have to *think* to understand how stars form — but thinking clears the mind. You feel good when you think. Now don't you wish you'd learned more about the stars when you were in school?

But because you're reading ASTRONOMY, I don't have to convince you how enjoyable astronomy can be. You already like the taste of astronomy. "Spinach," you say, "that's ridiculous. Astronomy's more like a chocolate eclair!"

But not everyone knows that — often because many people have never tried it. With ASTRONOMY, we're showing people that astronomy's not all "spinach."

The trick, of course, is getting people who don't know about astronomy to try it for the first time. You can introduce those people to astronomy and enhance your own enjoyment by sharing a tour of Copernicus crater with your friends, by showing some kids how to make a rummage-sale telescope really useful, by working to cut light pollution in your town so everyone can see the stars, or by offering a helping hand to the junior high science teacher in the classroom.

That's when you'll discover astronomy isn't a chocolate eclair — rich but full of air. Astronomy is an exciting banquet of ideas with something to suit everyone's taste. You'll find spinach, of course, and lots of other nourishing foods. And they're all good for you.

Sincerely,

Richard Berry

Richard Berry
Editor-in-Chief

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Letters

The New ASTRONOMY

Bravo! I find the new format most appealing and am quite thrilled with the content. Your new format comes right on the heels of my regained interest in observing the heavens and has added new fuel to my enthusiasm. — *Lee A. Phillips, San Diego, California*

Changing department names and locations within the magazine is one thing, but changing the overall appearance sharply degrades the magazine.

The articles and authors are still second to none. It's just that the magazine looks so much like *Sky & Telescope*. — *Randall De Arman, Birmingham, Alabama*

The July issue of ASTRONOMY could not be beat. ASTRONOMY is *the* magazine for amateurs, because the articles are what we are looking for to make the most of our hobby. — *Michael Dale Beck, Florence, Alabama*

I just received the July issue. Wow! what a difference! I love your new format.

The change in the Sky Almanac was the best I have seen so far. Not only was the almanac tastefully done, but the inclusion of more information is of immense value. — *James Moeller, Kirkville, New York*

Please return to the former Star Dome map in the center of the magazine. The new Sky Almanac doesn't have as much information, and the light blue background of the map doesn't show the stars as well as the old map did.

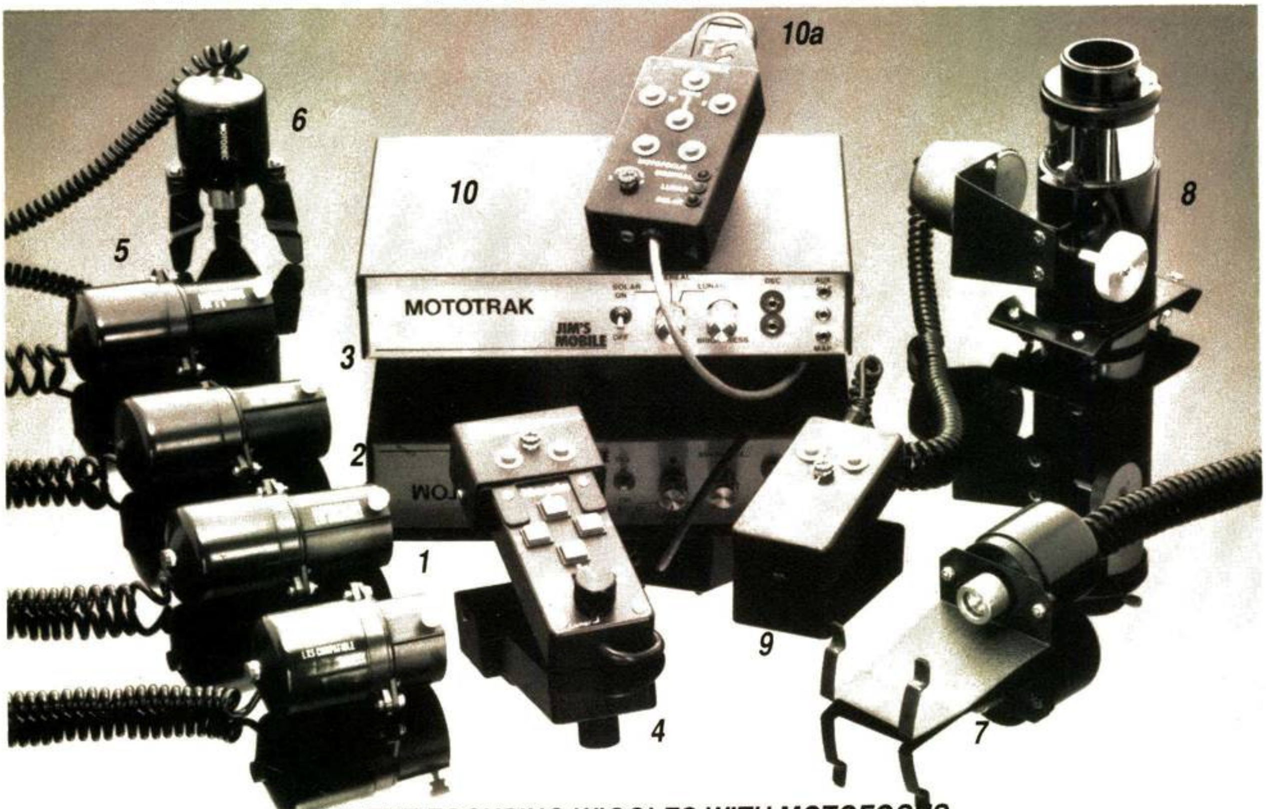
The only good part about the new format is the inclusion of the planets at mid-month. — *George Behr, Cresskill, New Jersey*

My deepest thanks for the new look of ASTRONOMY. Now even a novice like me can stand a chance of finding things in the night sky because of the wonderful new approach you've taken in Sky Almanac. Congratulations on a new look that is more informative and that works. — *Robert Shaw, New York, New York*

I was gravely disappointed to see that you dropped The Backyard Astronomer with the July issue. I have never missed reading the column, and every month I reread the previous year's column. — *Allen D. Timke, Washington, Illinois*

I was very pleased with the new format of ASTRONOMY, especially the Sky Almanac. However, though the magazine is better, I have a complaint.

NEW FROM JIM'S MOBILE

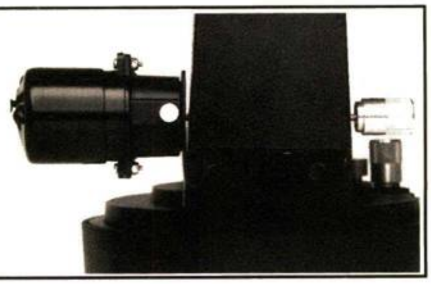


END THE FOCUSING WIGGLES WITH MOTOFOCUS

1. **NEW - MOTODEC PUSH-ON for all Meade fork mounted telescopes: 2080/2120, LX2, LX3, LX5 & MTS line** (MTS must have dec. shaft) ***$89.95***

The only dec. motor you can get:

a. with direct drive
b. with variable speed
c. without unsightly gears or belts
d. plus all the things you'd expect: easy-on easy-off, friction clutch, completely compatible with manufacturer's dual-axis hand control and looks so good you'll think it is original equipment.



2. **MOTOFOCUS for 2080/2120 LX5** Completely compatible with manufacturer's dual-axis hand control. Built-in variable speed control for fast focus as well as incredibly fine focusing action. ***$98.50***

3. **MOTOFOCUS for 2080/2120 LX2, LX3, MTS, GEM** Supplied with variable speed hand control and battery ***$98.50***

4. Battery operated focusing control attaches to Meade's LX3 hand control. When ordering MOTOFOCUS request **LX3 ATTACHMENT** at no extra cost.

5. **MOTOFOCUS for C-5/C-8** Available for all C-8's ever made (specify age). Equipped with variable speed control. Extremely easy to install. ***$89.95***
MOTOFOCUS for C-11/C-14 .... ***CALL***
DELUXE MOTOFOCUS for C-14 .... ***$149.95***
Controls r.a., dec., and focus. Plugs into Celestron's drive base.

6. **MOTODEC for C-8** This patented, snap-on dec. motor works so slick people have been seen on cloudy nights just snapping it on and off.
Friction drive ***$69.95***
With 8 rpm motor and built-in variable speed control ***$79.95***
SNAP-ON MOTODEC for C-11 .... ***CALL***

7. **SNAP-ON MOTODEC for Meade 2045, B&L 4000, 8000, 8001 & Dynamax/Criterion.** (Specify which scope) ***$69.95***
With 8 rpm motor & built-in variable speed control ***$79.95***

8. **MOTOFOCUS for Meade Newt. & Refr., Celestron Refr., Novak, Tele Vue Ren., Takahashi, Astro-Physics, University & Cave** ***$89.95***

9. **Hand unit with variable speed control** ***$20.00***
All declination motors work with dual-axis drive corrector or battery operated hand unit. A dual-control hand unit is free when ordering MOTOFOCUS and MOTODEC at the same time except for LX3 and LX5. LX3 & LX5 get $10.00 off.

10. **MOTOTRAK**, the only triple control drive corrector made. State-of-the-art. CMOS. QUARTZ DRIVEN. LED tracking indicators. Internal rechargeable battery will operate a C-11 9 hours. 10 watts.

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Order MOTOTRAK and get free MOTOFOCUS (motor assembly only) or Snap-On MOTODEC of your choice (Add $5.00 for shipping) ***$329.00***
Or order all three: MOTOTRAK, MOTODEC, MOTOFOCUS ***$389.00***

10-a **NEW! LCD TIMER ATTACHMENT for MOTOTRAK.** Time your exposures to the minute with this audible alarm ***$19.95***

OTHER PRODUCTS NOT PICTURED:
MOTOTRAK-G, the only triple-control drive corrector made for Meade GEM 2080/2120, 440, 295, 320, 6600, 8800. Battery operated, state-ot-the-art QUARTZ DRIVEN. Equipped with 2X, 8X.
MOTOTRAK-G for GEM with r.a. motor ... ***$229.00***
Declination motor ***$79.00***
MOTOFOCUS (Motor assembly only) ***$79.00***
Or order all three: **MOTOTRAK-G, MOTOFOCUS, MOTODEC** ***$359.00***
GEM OWNERS: Turn your single-axis into dual-axis. The only **declination motor** on the market for **GEM, Polaris, Tele Vue, Takahashi EM-1**. With variable speed hand control ***$98.50***
GEM DELUXE includes Motofocus, GEM declination & holder for Meade's #784 r.a. switch box .. ***$189.00***
MOTOFOCUS for B&L 4000 .... ***$89.95***
MOTOFOCUS for B&L 8001 .... ***$89.95***

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All snap-on MOTODEC products are protected by U.S. patent #4,709,178

The first thing I used to turn to was the "Best Astrophoto of the Month." I was very disappointed to find that the feature was dropped. Being an amateur photographer myself, I really enjoyed seeing other amateurs' work. — *Marion T. Fuller, Roseville, California*

The feature I most looked forward to is missing! The photos published in the "Best Astrophoto of the Month" really captured the heart of what I feel *is* astronomy.

This feature also gave astrophotographers tips about how to take better photos because the details of how the winning photo was taken were provided. The $100 prize made people want to take the best photo in the magazine. — *Jill Reese, Whittier, California*

I was disappointed to see that heliocentric longitudes are not listed in the new solar system section of the Sky Almanac. As a planetarian, I found this data invaluable for correcting the positions of the planets in the artificial sky and orrery.

You also devote a great deal of space to The Planets in Their Orbits, but you failed to reference the planetary positions to the stars.

I find your new, colorful format both easy to read and more informative. I appreciate more detailed information about transient phenomena, particularly comets, occultations, and asteroid locations. — *John H. Seago, Noble Planetarium, Fort Worth, Texas*

The Honest Quest

I found "Quest for the Most Distant Objects in the Universe" by Jeff Kanipe (June 1988) to be one of your best articles yet. It was one of those rare articles that demonstrates possibly the greatest aspect of astronomical science: the honesty to modify or reject theories when they have been proved wrong. This honesty seems especially important when cosmology is concerned. — *Leif E. Pierson, Farmers Branch, Texas*

Correction

The phone number published in the July Letters for the bulletin board through which you can receive the public domain software program, ASTROCLK, should be (213) 541-7299.

ASTRONOMY welcomes comments, suggestions, corrections, and additional information on articles and astronomy. Send your letters to: ASTRONOMY Letters, 1027 North 7th Street, Milwaukee WI 53233. Letters may be edited for length and clarity. □

Viewpoint

GET INVOLVED IN EDUCATION

by Andrew Fraknoi
Executive officer of the Astronomical Society of the Pacific, an international scientific and educational organization founded in 1889

Recent revelations about astrology in the White House probably caused most ASTRONOMY readers to chuckle and shake their heads in disbelief. But the popularity of "fiction sciences" like astrology is only one attention-grabbing symptom of the failure of the American educational system to teach youngsters about science and the scientific method.

Neither the level of teacher preparation in our country nor the degree of student achievement gives us cause for optimism. Consider these sobering statistics:

- Of the twenty-five classroom hours in a school week, the typical U.S. elementary school student receives only forty-four minutes of science instruction.
- During the 1985-86 school year only 57 percent of U.S. high school students were enrolled in any science course.
- In the Soviet Union, East Germany, China, and Japan, every student spends about three times as much time on math and science as the most science-oriented students in the United States.
- A recent study of Pacific Coast states showed that 84 percent of teachers newly assigned to teach science or math were not properly certified in those subjects.

The inadequacy of science education in America and the resulting scientific illiteracy of the public are problems that must be addressed on both state and federal levels. And notwithstanding Nancy Reagan's reliance on superstition, there are signs that some changes are under way. In the last few years several reports have focused attention on the problem and many states are increasing student science requirements and improving teacher training programs.

These efforts will take years to bear fruit, however. But astronomers and astronomy buffs can do something now to help the situation in our own communities. Astronomy and space hold a special fascination for most youngsters and are ideal vehicles for getting students interested in and excited about science.

One problem is that many teachers have little background in astronomy and are worried about teaching a subject that some of their brightest students may know more about than they do. Teachers tell me that even when they have the desire to teach modern astronomy, they are often foiled by outdated textbooks, lack of audio-visual and lab materials, and budget problems that make the likelihood of buying telescopes more remote than a quasar.

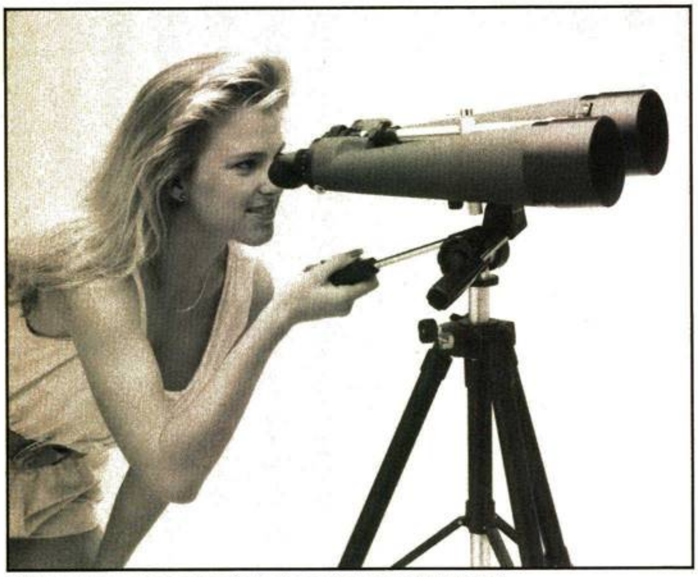
This is where community involvement can help. Let me propose a few concrete things ASTRONOMY readers can do to improve the teaching of astronomy.

1. Offer your services as an astronomy resource person to local schools. If you have a telescope, offer to lead a day or evening observing session. Even if you don't have much equipment, let teachers know of your willingness to answer questions and work with students.
2. Donate astronomy books and magazines you no longer want to school libraries, or sponsor a subscription to an astronomy magazine for your local library.
3. If you are a member of an astronomy group, organize school star parties or class programs as a regular part of your activities. At the very least, send regular announcements about your star parties and meetings to local teachers.
4. Get together with others who are interested in astronomy and sponsor a contest for your local school — for the best astronomy essay or astronomy-oriented science fair project, for example.
5. Become a volunteer at a local planetarium or science museum.
6. When your local media feature articles about pseudoscientific claims, take the time to share with the reporter or editor your excitement about the techniques and results of real science as well as your criticisms of astrology and UFOs.
7. If you are a good speaker, give a talk to a local youth group.

We who love astronomy must offer our help to teachers in our own communities.

It is time for us to recognize that we cannot sit at home and bemoan the state of science education or just dash off a letter to our elected officials and then forget the matter. We who love astronomy must speak out, offer our help, and contribute resources to make sure future generations know and love the stars as much as we do. □

NEW PRODUCTS FROM CELESTRON



100mm binoculars on a Celestron photographic tripod.

GIANT BINOCULARS

Celestron is proud to introduce two new models in our Giant series of binoculars. The newest models are the 14x100 and 20x100 units. These units provide excellent light gathering power with crisp, pinpoint star images. They offer even more breathtaking views than the 80mm size.

The standard 80mm models (11x80 and 20x80) are some of the finest premium 80mm units on the market. With their multi-coated high quality objectives and eyepieces and superior BAK-4 prisms, the resulting image quality is far superior to competitive units using BK-7 prisms and standard coatings. The objectives are supported by a mounting brace for stability—a feature not found on many other models.

The Deluxe 14x80 and 20x80 models have established a market niche for the discriminating 80mm size buyer. Mechanically they are extremely stable with rigid reinforcement from front to back.

All of the binoculars in the Giant series are multi-coated and utilize BAK-4 prisms. All come standard with a photo tripod adapter, lens caps and newly improved deluxe carrying case. Besides the astronomical applications these binoculars were designed for, they are excellent terrestrial performers as well, particularly in low-light conditions.

A complete brochure on all Celestron binoculars is available.

Contact your Celestron dealer for information or send $1.00 to cover postage & handling to:

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COLORED EYEPIECE FILTERS

Celestron is pleased to offer the finest and most extensive line of colored eyepiece filters available to the amateur astronomer. These filters are an invaluable aid to lunar and planetary observers. They reduce glare and light scattering, increase contrast by selective filtration, increase definition and resolution, reduce atmospheric refraction, reduce irradiation and lessen eye fatigue.

The filters are threaded to fit Celestron and most other manufacturers' 1¼" eyepieces. They are a full *26mm* clear aperture. Premium quality, solid plane parallel glass with excellent homogeneity is utilized. The filters are anti-reflection coated on *both* sides of the glass to prevent glare and ghosting. The Kodak Wratten Series number is engraved on each unit which is housed in a black aluminum cell and double-threaded to allow for stacking (piggyback) applications.

Wratten Series numbers available are: #1A, #8, #12, #15, #21, #23A, #25, #30, #38A, #47, #56, #58, #80A, #82A, #96 (0.3, 0.6, 0.9), #Polarizer.

Top: Left-to-Right: Polarizing filter set, filter adapter and reducing bushing. Bottom: Eyepiece filters.

A Polarizing Filter Set is offered for variable-density usage. Operation is easy, you need only rotate the eyepiece. The Filter Adapter is a useful accessory allowing you to use these filters with any 1¼" eyepiece. It also allows you to utilize the same filter with different magnifications more easily. The Reducing Bushing allows you to use 1¼" eyepieces and these filters with instruments normally using .96" eyepieces.

A 4-page brochure is available giving complete details on the usage of each filter and the accessory items available for each.

OLD GALAXY, YOUNG UNIVERSE

The discovery of an old, massive spiral galaxy at a distance corresponding to an epoch when the universe was only one tenth its present age may provide astronomers with a firsthand look at galaxy formation and star birth in the early universe.

Simon Lilly, an astronomer at the University of Hawaii at Manoa, discovered the galaxy in the course of pairing radio sources with their optical counterparts. Lilly first detected object 0902+34 in 1985 as a faint infrared source with the 3.8-meter United Kingdom Infrared Telescope (UKIRT) on Mauna Kea, Hawaii. He followed up this observation by obtaining visible-light and improved infrared images at both the UKIRT and the 3.6-meter Canada-France-Hawaii Telescope on Mauna Kea.

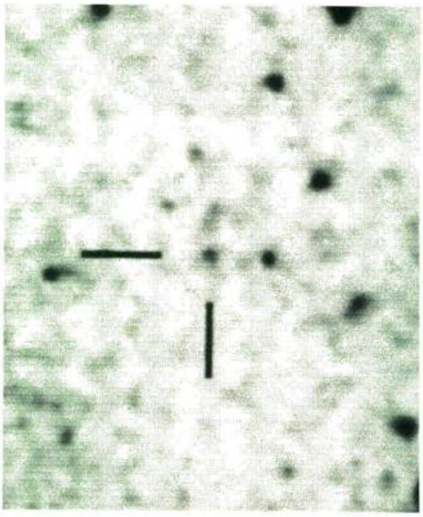
In November 1987 he obtained a spectrogram of the object with a faint-object spectrograph coupled with the Canada-France-Hawaii Telescope. The spectrum showed the prominent ultraviolet hydrogen emission line, known as Lyman alpha, shifted 340 percent into the visual part of the spectrum. This means the object has a redshift of 3.4 and lies at a distance of about 11.6 billion light-years, which makes it the most distant galaxy yet identified.

One reason this object is considered a galaxy is its angular extent in the sky. Unlike high-redshift quasars, 0902+34 is not a starlike point but covers an area 7 arcseconds by 4 arcseconds in size.

An analysis of the galaxy's spectrum reveals the presence of both young and old stars. The presence of hot, young, blue stars indicates significant ongoing star birth. By Lilly's calculations, approximately 100 solar masses of interstellar matter are being converted into stars per year. But the old stars, which are responsible for the increased brightness at infrared wavelengths, are between 1 billion and 2 billion years old and account for about 90 percent of the total mass of the galaxy. According to Lilly, this means the galaxy formed at an even earlier time in the history of the universe.

"It's the first time we've ever seen a convincing stellar population that far back in time," said Lilly. "This allows us to see a galaxy at an epoch where our theories tell us that galaxy formation may have been happening."

The discovery of this galaxy may also challenge astronomers' best theory of galaxy formation — the cold dark matter model — which states that the first galaxies formed no earlier than a redshift of 5, a little over 12 billion years ago. According to the standard cold dark matter theory, there shouldn't be very many galaxies as well formed as 0902+34 at a redshift of 3.4. Nevertheless, Lilly thinks it possible for other high-redshift radio galaxies to exist. "I think we'll probably find one or two more. It's pretty inconceivable that there are no radio galaxies in the distant universe."



THE MOST DISTANT GALAXY yet detected, 0902+34, lies at a redshift of 3.4 and provides astronomers with the opportunity to study the properties of a galaxy that existed when the universe was young.

Lilly believes it's far too early to rule out the cold dark matter model. "I think we'll see an evolution of this topic in which we realize the cold dark matter model needs to be reworked. I don't think we should underestimate what the theorists can wiggle through."

COMETS LEVY AND SHOEMAKER-HOLT RELATED

In mid-May 1988 astronomers at the Center for Astrophysics in Cambridge, Massachusetts discovered that two recently discovered comets have nearly identical orbits. That comets Levy (1988e) and Shoemaker-Holt (1988g) have the same orbit but perihelion dates 76 days apart can only mean one thing: the two comets were once one.

Comet Levy was discovered by Arizona comet hunter David H. Levy on March 19, 1988. At the time it shone at 11th magnitude and slowly faded, which made high-quality observations of the comet difficult. Carolyn and Eugene Shoemaker and Henry Holt of Palomar Observatory found Comet Shoemaker-Holt, also an 11th-magnitude object, on May 13, 1988. Because Shoemaker-Holt faded more slowly, astronomers could study it more thoroughly than Comet Levy.

A few days after the discovery of Shoemaker-Holt, Brian Marsden and C. M. Bardwell of the Center for Astrophysics calculated an orbit for Shoemaker-Holt and found that it was almost identical to that of Comet Levy. The perihelion dates for Levy and Shoemaker-Holt were found to be November 29, 1987, and February 13, 1988, respectively.

"It's a mystery at this point," said Marsden. "If the comets had a very large difference in perihelion dates or a very small one, we could understand that the comets could have split apart from each other." Astronomers know of related comet fragments having very small and very large differences in perihelion dates.

Marsden believes it's possible that the comets broke apart differently than the few fragmented comets observed in the past. "As a working hypothesis," Marsden explained, "I'm supposing that when the comets were previously at perihelion, 20,000 years ago, maybe the comet cracked. It didn't actually split into two fragments but weakened near the Sun. Somehow the two fragments remained stuck together until the comet was way out beyond the orbit of Neptune. Something triggered the final jolt that was needed to break the pieces from each other. And when they returned to perihelion recently, we initially thought the two fragments were separate comets. It's very exciting, because this scenario is something we've never dealt with before."

CLOSE BINARY STARS AND PLANETARY NEBULAE

Seven thousand light-years from Earth a planetary nebula designated K 1-2 contains a binary star system that is providing astronomers with crucial pieces to an astrophysical puzzle. In a kind of cosmic snapshot, K 1-2 is showing how binary

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star systems can evolve.

Astronomer Howard Bond of the Space Telescope Science Institute in Baltimore observed K 1-2 from Cerro Tololo Inter-american Observatory in Chile earlier this year. The planetary nebula had been found by Lubos Kohoutek in 1964 in the southern constellation Pyxis. Kohoutek noticed that the central star in K 1-2 varied in brightness but was unable to investigate further.

Bond's observations established that the central star's brightness ranges from magnitude 16.8 to 18.0 over a period of 16 hours 13 minutes. The fast period indicates that K 1-2's central "star" is a close binary system, and the picture that soon emerged has a blue-white star and a reddish orange star orbiting a common center of mass.

"I think it's a very near thing," said Bond, "but they don't quite eclipse each other."

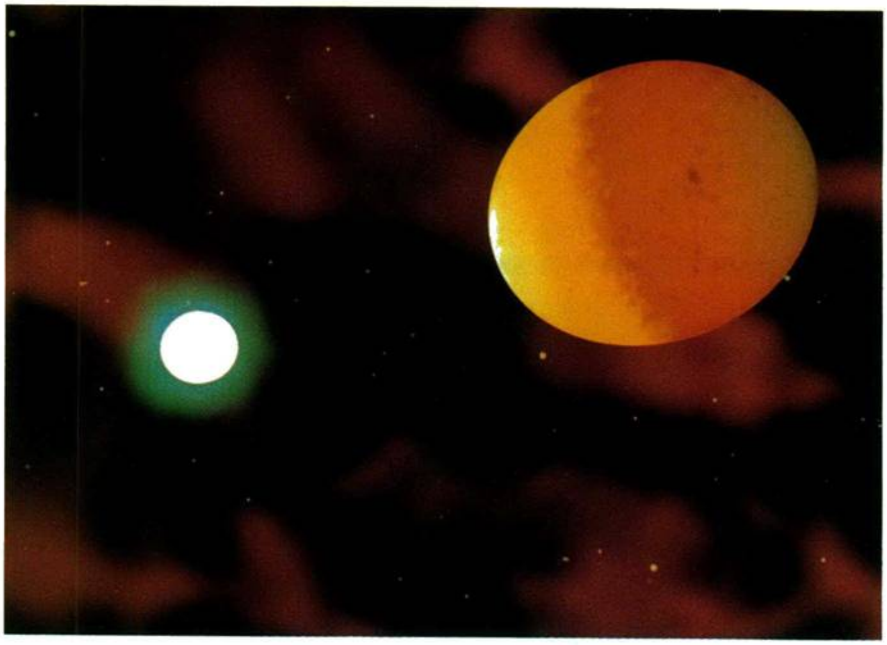
Tidal forces from the more massive hot star have slowed the rotation of the cool companion star so that the companion probably keeps one face turned toward the primary all the time. The same forces have stretched the companion into an egg shape.

"The brightness varies because the side of the orange star that faces the hot primary is heated to about 10,000 to 12,000 kelvins — white-hot," explained Bond. "Whenever the orange star lies on the far side of the primary from us, its hot side is turned our way and the system as a whole looks brighter."

Bond's results on K 1-2 are part of a search he and his colleagues (Robin Ciardullo of Kitt Peak National Observatory and Albert Grauer of the University of Arkansas) are conducting to examine the central stars in other planetary nebulae. So far eight double star systems in fifty planetary nebulae have been found. "When we've looked at many more planetary nebulae," Bond said, "the percentage that turns out to have close binary central stars like K 1-2 will probably remain close to 15 percent. But if we start looking for systems with wider separations, that 15 percent figure might go up a lot."

The astrophysical importance of K 1-2 (and similar objects) lies in the solution it offers astronomers to a long-standing question: How does nature make a close binary system? Because wide binary stars are abundant, the problem is finding a way to get the stars in an ordinary binary system to move closer together. The trick seems to lie in the changes stars go through as they age.

A system like K 1-2 might take the following course as it grows older. At first the stars orbit at some fairly wide separation. Then the more massive primary star evolves to become a red giant, swelling its outermost layers beyond the orbit of the secondary star. This slows the primary star's rotation and exerts a drag on the companion, which finds itself orbiting *inside* the primary's outer envelope. Losing orbital energy, it slowly spirals inward.



A BINARY STAR SYSTEM, with one member egg-shaped under tidal forces, lies at the heart of the planetary nebula K 1-2.

Eventually the primary star discards its outer layers completely and is reduced to its hot core. By this time the secondary is orbiting close to it and the discarded gas from the primary has formed a diffuse shell — a planetary nebula — around the pair. This is the stage K 1-2 is at now.

When the primary star stops shedding its extended envelope, the secondary's orbit slows its inward spiral. The main braking effect to operate on the secondary then comes from the interaction of its magnetic field on its own stellar wind. After a few billion more years pass, the secondary star will move in so close that the primary star's tides can start to rip gas away from it. The gas will eventually fall onto the primary, where it will heat up until a thermonuclear reaction detonates, producing a nova explosion.

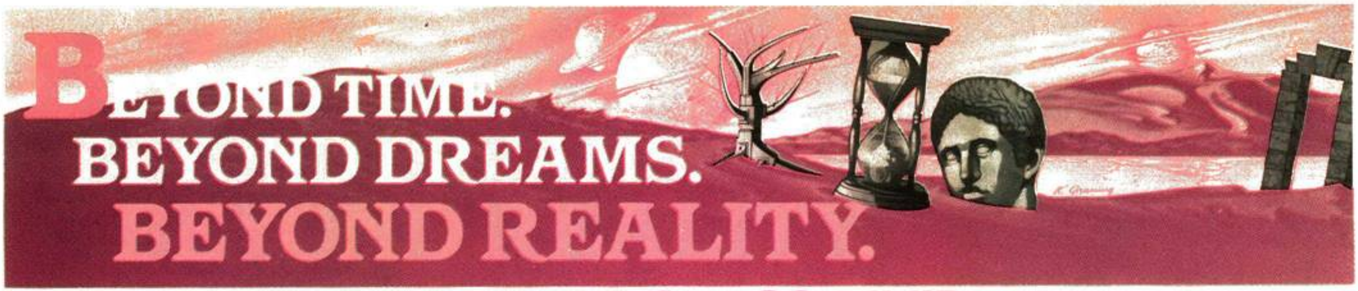
IS THE OORT CLOUD PRISTINE?

In cold, dark space, 50,000 astronomical units from Earth — roughly 1 light-year — a trillion comets slowly orbit the distant Sun. Planetary scientists call this assemblage the Oort cloud, after the Dutch astronomer who postulated its existence in the 1950s.

Scientists envision the Oort cloud as a deepfreeze that preserves comets in a state very close to the early solar nebula they formed from. The ambient temperature in the cloud hovers around 4 kelvins (−452° F) — cold enough to keep everything except helium frozen rock solid. From time to time a "new" comet from the cloud swings through the inner solar system and astronomers see material essentially unchanged over the 4.5 billion-year age of the system.

But if Alan Stern and Michael Shull of the University of Colorado at Boulder are right, these supposedly untouched relics are not pristine at all. Their work, reported in *Nature* (March 31, 1988), shows that no comet in the cloud has escaped being singed by the heat of passing stars and that planetary science's "Holy Grail" — unaltered pieces of the early solar nebula — may not be exposed anywhere in the solar system.

Shull and Stern examined the effects of encounters with passing stars and nearby nova and supernova explosions on the conventional model for the cloud. They found, surprisingly, that no comet has remained unaffected. While Oort cloud comets spend most of the time hibernating quietly at 4 kelvins as astronomers thought, every comet in the cloud has nonetheless been heated about twenty-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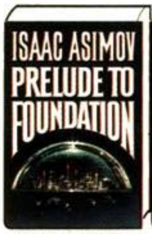
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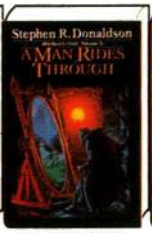
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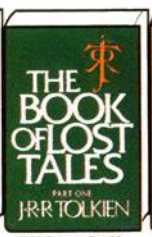
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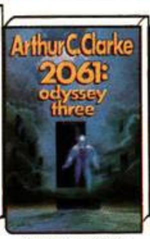
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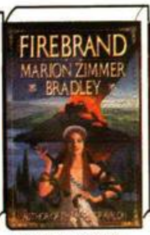
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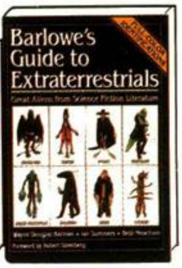
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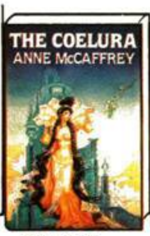
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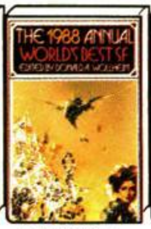
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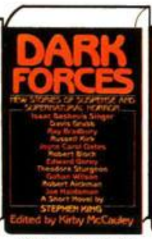
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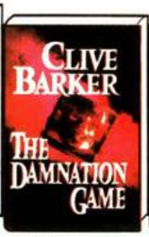
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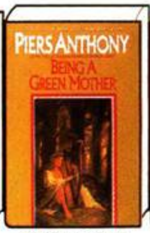
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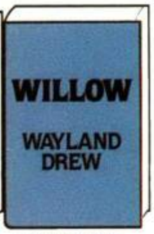
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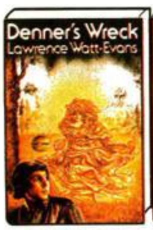
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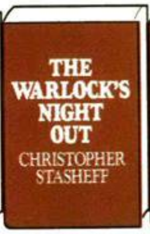
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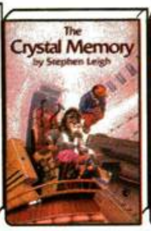
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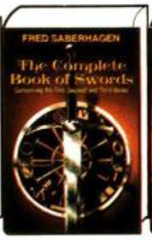
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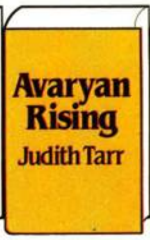
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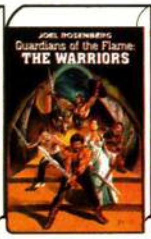
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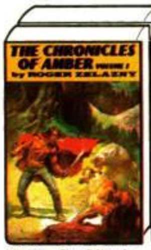
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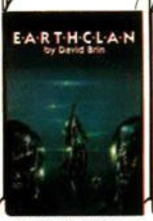
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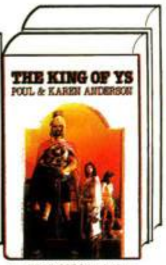
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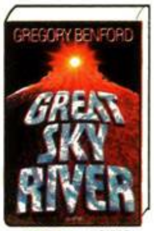
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five times to a temperature of 30 kelvins and at least once to 50 kelvins.

Stern and Shull first examined the effects of stars passing through (or near) the cloud and then calculated the effects of novae and supernovae using estimated rates of occurrence. With stars, supergiants turned out to have the greatest impact. As main-sequence stars bore through the cloud, they heat only a "pencil-thin tunnel," 10 to 100 astronomical units across. But highly luminous supergiants, many of them hot O- and B-type stars, dominate the heating because they are fairly numerous, very bright, and tend to collect in groups. Stern and Shull note that while an encounter between the cloud and a G-type star like the Sun might last ten years, "each luminous [O-type] star causes comets to bask in an elevated radiation field for about 10,000 years."

Between nova and supernova explosions, the latter play a much greater role. While novae occur roughly a thousand times more often than supernovae, each supernova is about ten thousand times more powerful than any given nova. Therefore, supernovae contribute about ten times more radiant energy to interstellar space.

The two processes — star encounters and supernovae — also differ in what they do to a comet. The typical supernova will "flash" the comet, briefly heating the surface to a relatively high temperature. A passing star, however, will spend years in a comet's vicinity, during which as much as 20 percent of the comet's mass will slowly warm to a somewhat lower temperature. Calculations show that the stellar-encounter process induces more profound changes.

If Stern and Shull's research diminishes the chances of seeing untouched remnants of the early solar nebula, it still opens up exciting prospects. First, while comet material may not be pristine, understanding its physical and chemical changes means scientists can make more intelligent use of their observations. "Everyone used to think the cloud was like an icebox whose door had been shut since the system formed," said Stern. "That's too simplistic — in reality the door gets left open a little now and then."

Second, the gas liberated from Oort cloud comets during a stellar encounter should be visible as a glow in the far ultraviolet part of the spectrum. This means that extrasolar Oort clouds (and other solar systems) might be detected this way. Stern and Shull intend to look for ultraviolet haloes surrounding stellar pairs where an O-type star lies close to a main-sequence star.

Space News

BRITISH VETO FREEZES ESA BUDGET

NASA isn't the only space agency facing funding problems these days. The European Space Agency (ESA) recently encountered a freeze on its five-year budget when Great Britain vetoed a 5 percent budget increase for ESA's mandatory space science program.

ESA is composed of thirteen Western European countries that jointly support space research and technology. Each country contributes to the mandatory space program based on the country's national income. ESA's mandatory space program, called Horizon 2000.0, funds projects in four areas: solar-terrestrial physics, x-ray astronomy, submillimeter astronomy, and samples from comet nuclei. Horizon 2000.0 was unanimously approved by ESA member states in 1985.

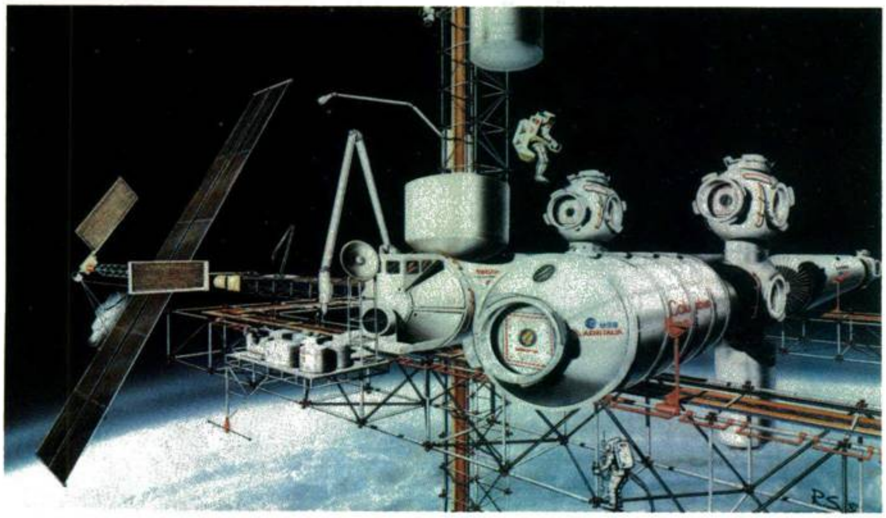
Unlike NASA, which is one of many governmental agencies that gets only a slice of the federal budget, ESA has its own pie to slice up into various space projects. There are also optional projects, like the *Ariane* rockets, which member countries fund separately from the mandatory program.

When ESA's policy-making body met last November to vote on a 5 percent spending increase for the next five years, Britain was able to single-handedly freeze ESA's budget at current levels by vetoing the increase. (ESA budget decisions must be unanimous.) The budget increase would have amounted to approximately $8 million more per year for the ESA mandatory program; Britain's contribution would have been approximately $600,000 more per year.

"Our objection is not solely that the bill is so huge," said Kenneth Clarke, Britain's space minister, in a speech to the House of Commons after returning from ESA's budget meeting. "We recognize that space research is expensive, but we cannot see sufficient scientific, industrial, or commercial benefits to justify such a huge increase."

Under ESA rules the other twelve member states cannot increase their spending levels to compensate for the budget freeze.

Britain also declined last year to support development of three optional ESA programs: the *Ariane 5* rocket, the *Columbus* space station, and the *Hermes* spaceplane. Britain had previously agreed to fund 13 percent of the development costs of *Columbus*, ESA's contribution to the U.S. space station. *Columbus* has three elements: a manned laboratory module attached to the Space Station; an orbiting laboratory that astronauts can visit to change experiments; and a polar platform, a new type of remote-sensing satellite designed to orbit Earth permanently. Britain was primarily interested in the polar platform.



ALTHOUGH BRITAIN RESTORED its support of Columbus, the European Space Agency's contribution to the Space Station, it refuses to support an increase for ESA's mandatory program.

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". . . so quick you really *can* observe 100 objects an hour, as the ads say . . . If you prefer to spend your time observing deep-sky sights rather than hunting for them, then the CAT is ideal."— *Sky & Telescope*, November, 1987.

". . . the CAT is a true time saver, a device that can show hundreds of objects per night . . . the payoff is an automated, self-guided tour of the universe." — *Astronomy*, December, 1987.

What it is: The Meade CAT ("Computer Aided Telescope") system is a revolutionary telescope accessory that leads Schmidt-Cassegrain telescopes from object to object, in *seconds.* The graphic display on the CAT's console enables the observer to locate *any object in the CAT's 8,199-object memory within, literally, 5 to 10 seconds or less.*

How it works: Included with the CAT are 2 precision optical encoders that mount on the telescope and sense the telescope's position in RA and Dec; the encoders permit the location of even the most obscure objects with 25 times the precision of standard setting circles. Using the CAT's large, red-illuminated crossline display, the observer manually moves the telescope to the position dictated by the crosslines. The CAT unerringly positions the desired object precisely in the center of the telescopic field. In addition, digital readouts on the display console continuously display R.A. and Declination.

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CAT #9003: for C8 fork-mounted models	**1495**
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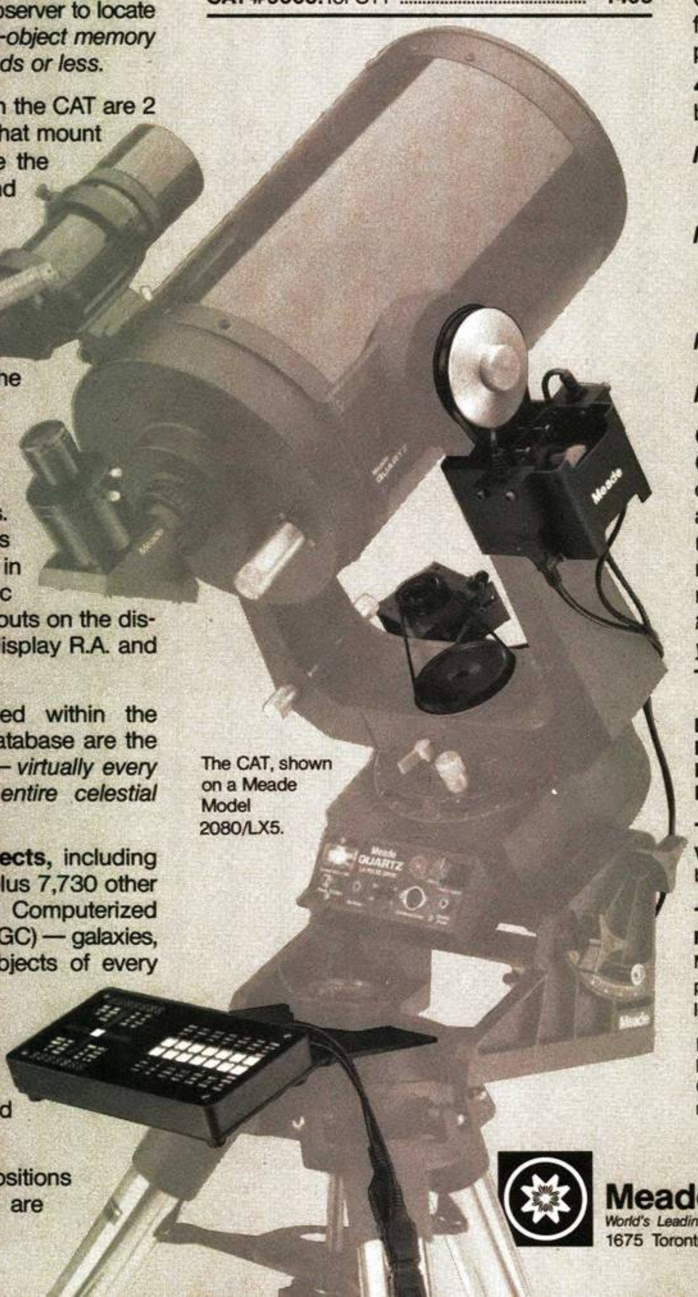

The CAT, shown on a Meade Model 2080/LX5.

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Mode 2: reads telescope Right Ascension and Declination. R.A. reads out to a precision of 1-min., Dec to 0.1°.
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Optical Encoders: Meade Digital Setting Circles utilize Hewlett-Packard optical encoders for the highest level of precision and sensitivity. The encoders attach in minutes to the polar and Dec. axes. The readout unit mounts onto the telescope's rear cell, where it is *continuously visible from the eyepiece observing position as you move from object to object.*

Models and Pricing

DSC #9060: for all Meade 2080 models	**$495**
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DSC #9065: for C11	**495**

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Because ESA has a policy of "fair return," which means a country gets back in contracts the money it contributes toward an optional project, Britain also stood to lose the space contracts the three optional projects would have returned to the British National Space Centre and British aerospace industries.

In January the House of Lords released a report that severely criticized Britain's space policy. "The UK should play a more constructive role in ESA," according to the report. The report also advocated British participation in *Columbus* and at least minimal participation in *Ariane 5*, a new heavy launch rocket ESA is developing.

Last April Britain reversed its decision on *Columbus* and agreed to participate in the program after the cost and weight of the polar platform were reduced. The platform will not be serviced by humans, as originally planned. This results in a savings of approximately $100 million, which reduces the cost of the platform from $275 million to $175 million. Britain plans to contribute about $140 million to the $1.5 billion *Columbus* project.

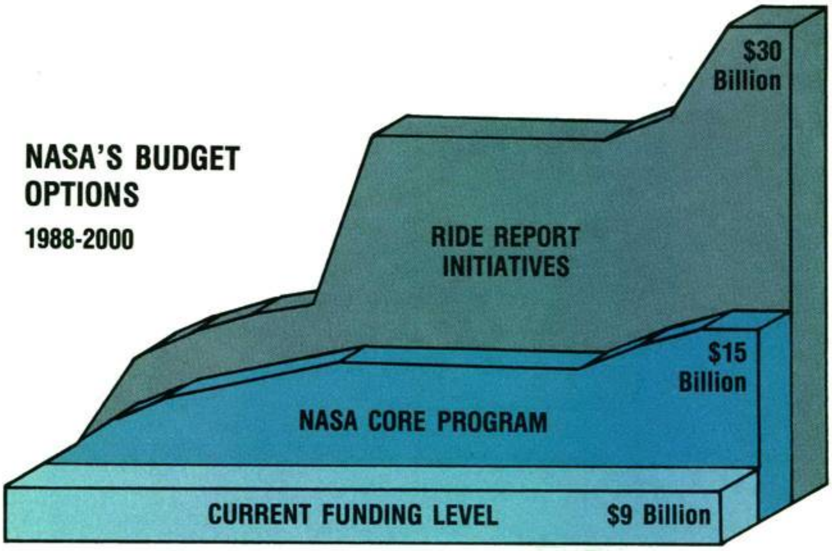
Britain's veto of the increased funding for the mandatory space science program still stands, however. ESA is currently reevaluating its budget to determine the effect of the freeze on its projects. Among the possible choices ESA faces are changing its rules to allow other member states to make up for the shortfall or either cutting back or delaying mandatory science missions.

NASA'S FUTURE: GROWING, SHRINKING, OR STATUS QUO?

This is the year that the fate of America's space program must be decided. According to a Congressional Budget Office report on NASA in the 1990s, Congress must make a fundamental decision in this year's budget deliberations: Should NASA's budget be allowed to grow gradually to fulfill current plans, should it be increased dramatically to pursue new initiatives, or should it be frozen at its current level?

For NASA to pursue its "core" program, which includes the Space Station and current science missions, the agency's budget will have to grow. A 27 percent increase over last year's $9 billion budget is requested for 1989; by the year 2000 NASA's budget would be $15 billion.

If Congress wants to pursue major new manned missions like those outlined in the Ride Report (ASTRONOMY, January 1988), NASA's budget will need to grow rapidly throughout the 1990s to as much as $30 billion in the year 2000.



"If [Congress] seeks international leadership — particularly in manned exploration of the solar system — then it must allow for as much as a threefold increase in NASA's spending over the next decade," the report stated.

On the other hand, if Congress wants to spend the American people's money on things other than space, it could decide to freeze NASA's budget at its current level. Under a no-growth budget, NASA would either have to delay or cancel many of its programs, including the Space Station. "Leadership in manned operations in low Earth orbit or manned exploration of the solar system would be abandoned." U.S. manned space activities would not proceed beyond *Spacelab* shuttle missions and periodic trips to an orbiting laboratory.

Amateur News

CELEBRATING MARS THIS FALL

To celebrate the best apparition of Mars in seventeen years this September, "Mars Mania" events ranging from public telescope observing to Martian costume parties will offer the public a chance to get better acquainted with Mars.

"The public is very interested in Mars," said Susan Lendroth of the Planetary Society in Pasadena, California, which is providing Mars information kits to the public. "People are really interested in seeing the surface features of a planet from Earth," Lendroth said.

By June the Planetary Society had already sent out five thousand "Mars Watch '88" information kits, which include a fact and observing sheet and guidelines for Mars events.

There will be plenty of opportunities for the public to observe Mars this fall at the most popular type of Mars event, the star party. Astronomy clubs and planetariums will set up their telescopes and invite the public to take a look at the Red Planet this September.

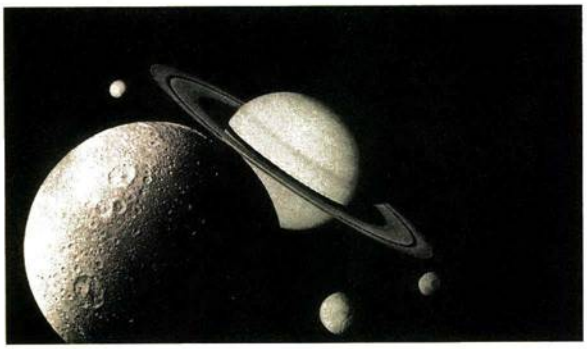
Star parties are also being held in conjunction with other special events, like lectures on the geology of Mars and what we've learned from space missions to the planet. The Patterson Planetarium in Columbus, Georgia, for instance, will hold three star parties in September after its Mars program and expects up to three hundred people to attend each one.

Adler Planetarium in Chicago will offer two unique ways to view Mars. With a charge-coupled device attached to the new 20-inch telescope, live pictures of Mars will be displayed over an 18-foot by 24-foot area of the planetarium dome. Adler will also be exhibiting meteorites, believed to have come from Mars. Attendance for all Mars planetarium programs is expected to be 100,000.

Another focus for Mars events is future space exploration. In a four-lecture series sponsored by the Alberta Science Centre in Calgary and the Edmonton Space Sciences Centre two lectures will focus on U.S. and Soviet Mars plans, respectively. A representative from NASA and from the Soviet Academy of Sciences will present two lectures, and author Terence Dickinson and planetary scientist Hal Masursky will present the other two lectures in the series. The series will run from September 12 to October 4.

This fall's apparition of Mars coincides

Does exploring other worlds make your heart beat faster?



Help launch a new era in planetary exploration… and enjoy the many benefits of membership in The Planetary Society.

This is an important time for space exploration enthusiasts like you. At no other time in history has the exploration of other worlds held more promise. Through your membership in The Planetary Society, *you* can help fulfill this promise…*you* can have an impact on the exploration of other worlds and the search for extraterrestrial intelligence.

In the last two decades, for the first time in history, we have studied our neighboring worlds close up and in detail—the enigmatic pyramids of Mars, the organic clouds of Titan, the 10,000 Saturnian rings. Right now, the U.S., the U.S.S.R., the European Space Agency and Japan are planning historic space missions. These epic ventures will be remembered by our descendants thousands of years from now when most other achievements of our time will be forgotten.

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Headed by some of the world's most distinguished scientists, The Planetary Society provides more than 100,000 members with knowledge and inspiration that sparks their imaginations and keeps them on the cutting edge of space exploration.

U.S. Planetary missions scuttled. New hopes for new missions.

Since 1978, the U.S. has not launched a single mission to the planets—after dozens of historic missions in the preceding two decades. Today, The Planetary Society is spearheading efforts to renew U.S. commitment to missions awaiting launch: *Galileo, Magellan, Ulysses* and *Mars Observer.* And we are disseminating information to the American people on the ambitious Soviet *Phobos* mission and on future Soviet Mars exploration. We are also leading the drive for a multinational piloted mission to Mars and new expeditions to other planets. We invite you to join us.

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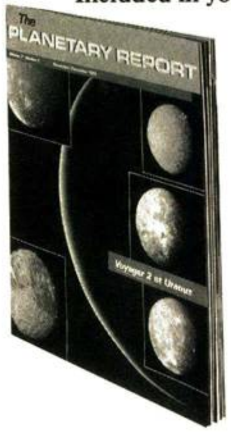

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Co-founders of The Planetary Society: Bruce Murray, Professor of Planetary Sciences, California Institute of Technology (seated left); Carl Sagan, Director, Laboratory for Planetary Studies, Cornell University (seated right); Louis Friedman, Executive Director (standing).

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with the fiftieth anniversary of Orson Welles' radio broadcast of "The War of the Worlds," on October 31, so many groups like the Florida Space Society will be replaying this fictional account of a Martian attack on Earth as part of their Mars celebrations.

Take advantage of the rampant Mars Mania to get better acquainted with the Red Planet this fall. Contact your local astronomy club and check the Meetings and Events calendar on page 106 for Mars events in your area.

LOS ANGELES 31-INCH SEES FIRST LIGHT

Only one year after starting work on a new 31-inch Newtonian telescope, the Los Angeles Astronomical Society put the telescope into operation. Although the computerized tracking and finding system isn't finished yet, hundreds of people looked through the telescope at the 1988 Riverside Telescope Makers Conference.

Like some kind of knocked-down oil rig, the telescope arrived at the RTMC on a large trailer. Under LAAS president Tom Dorff's command, the troops of the LAAS telescope brigade grunted and tugged and bolted the telescope's heavy parts into place. Friday night a long line of people waited for a chance to climb the eight-foot observing platform for a brief look through the eyepiece.

"We had tremendous cooperation from our members in building the telescope," said Dorff. "Over forty members have worked on it." Tasks ranged from making the secondary mirrors to sewing a cloth light shield for the upper end.

Because Pluto-discoverer Clyde Tombaugh was instrumental in obtaining the 31-inch f/4.6 primary mirror from an anonymous donor, the telescope was dubbed the "Clyde-O-Scope" in Tombaugh's honor. The massive telescope can be used as a standard Newtonian, as a folded Newtonian with a 10-inch flat made in the LAAS optical shop, or with either of two Cassegrain secondaries — one providing an f/12 focus and the other an f/20 focus.

The telescope stands over ten feet tall and is constructed of welded steel. A large steel rocker box carries the tube, but the telescope is a Dobsonian in appearance only. Using stepper motors to drive the telescope and an onboard computer to control the motors, club members hope to make the altazimuth telescope track the sky and, with the aid of an object database stored in the computer, locate deep-sky objects automatically.

Faced with the high cost of buying a three-foot-diameter bearing for the azimuth axis, club members made one themselves instead. Dorff explained that club members cut two thick steel plates and turned grooves in the plates with a lathe. "We poured nearly a thousand ball bearings into the groove," said Steve Kufeld. The result is an enormous and inexpensive turntable for the telescope.

"A year ago we had only the mirror," said Dorff, "and now we have a working telescope." Large telescope projects often take a decade or more. Club members credited Dorff's strong leadership for the speed with which the telescope has been built.

LOS ANGELES
ASTRONOMICAL
SOCIETY
INFORMATION

PROUD OF THEIR NEW SCOPE, members of the Los Angeles Astronomical Society showed their handiwork at this year's Riverside Telescope Makers Conference.

BIG CROWD AT 20TH RIVERSIDE TELESCOPE CONFERENCE

Over 1,800 telescope makers attended the twentieth meeting of the Riverside Telescope Makers Conference, held annually near Big Bear Lake, California, over the Memorial Day weekend. But strong winds, clouds, and even a touch of snow conspired against the three-day conference and forced builders to wrap their creations in plastic or put them away. Only Friday afternoon and Saturday morning offered clement weather for telescope exhibitors.

Riverside's twentieth year was not a year of startling innovation in telescope design. But it was a year in which telescope builders refined and developed older ideas, tested variations on established designs, and showed off bigger telescopes. Commercial displays were also a major attraction, with "show special" and "slightly damaged" merchandise selling for 50 to 80 percent off retail price. Vendors said that eyepieces, binoculars, T-shirts, star atlases, focusers, and filters all sold very well this year.

Stealing the show was the Los Angeles Astronomical Society's 31-inch Newtonian telescope (see story at left). Hundreds of observers stood in line Friday night waiting for a chance to look through the new telescope. Although the light of the Full Moon washed out faint deep-sky details, observers said they were impressed by how much they *could* see under such conditions.

About one hundred amateur telescopes were brought to the conference, and nearly forty telescope makers entered their creations for Merit Awards judging. Given in recognition of outstanding telescope designs, innovative approaches, and craftsmanship, Merit Awards are noncompetitive.

"I'm happy to see that more people were building telescopes this year," said Randy Wilcox, chair of the Merit Awards committee, "and that some people were even pushing glass." Grinding and polishing the mirrors for telescopes — "pushing glass" — is the traditional measure of dedication to telescope making. The committee selected thirteen telescopes for Merit Awards.

The Warren Estes Award recognizes another tradition of amateur telescope making — building telescopes from materials most people consider junk. Given for the best use of scrap materials, this year's award went to Douglas Ostroski for a good-looking and functional split-ring equatorial mounting for a 17.5-inch Newtonian reflector that cost Ostroski only $68 out of pocket. ☐

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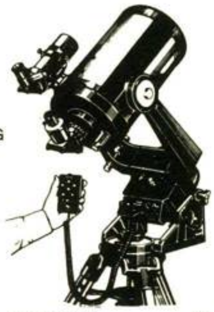

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SP-C8 .... (List: $1,620) .... $ 917.95
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PowerStar-C8 III (List: $2,700) $1,587.95
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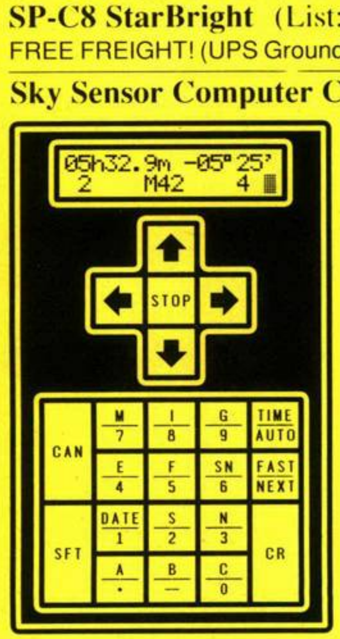
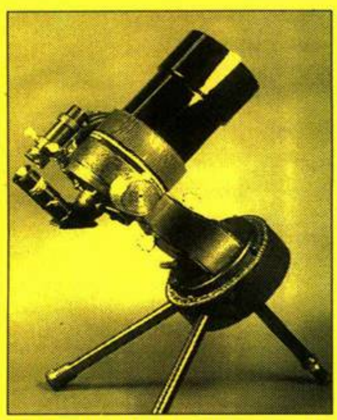
Sky Sensor Computer Control for Super Polaris



The ***Super Polaris*** German equatorial mount is one of the most useful general purpose astronomical mounts for amateur astronomers and astrophotographers. One aspect of its "application flexibility" is the variety of motor drives made for it. Very sophisticated single axis, dual-axis and dual axis computer (***SkySensor***) quartz regulated, micro electronic pulse motor drives are available for the ***Super Polaris***, and are easily attached or dismounted by means of a few screws. Of these three drives, the ***SkySensor*** is the most advanced and interesting: it is actually a very powerful ***telescope-controlling computer***, with an internally-stored catalog of 762 astronomical objects. The computer itself has 22 command/control keys (14 of which are dual function), as well as a 32-character, alphanumeric liquid-crystal display. Capable of slewing the mount at 15 arcmin/sec/axis, ***Skysensor's*** dual axis motors can point your telescope at any of the internally cataloged objects, or at any other object whose coordinates you input. In addition, ***SkySensor*** provides ***complete manual control*** of the telescope's motions, at both the slew and "photographic guiding" speed rates, by means of its manual motion-control keys. Finally, for those who are "computer literate" (not for novices), ***SkySensor*** is also equipped with an RS 232 C serial communication port, by means of which a personal computer may be electronically "piggybacked" onto ***SkySensor***, to take control of it. The ***SkySensor*** instruction manual covers the PC computer command structure for ***SkySensor***, and even includes some sample BASIC source code. Complete kit includes ***SkySensor***, stepper motors, drive gearing & clutches, bracketing, tools, cables, instructions & hardcopy of the stored object catalog *(12VDC power supply **not** included).*

SkySensor .. (List: $950.00) $599.95

Dual-Axis .. (List: $380.00) $269.95
Single-Axis (List: $220.00) $149.95



C90 Astro

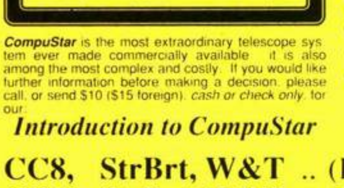
The C90 Astronomical Telescope is the only reasonably priced, truly portable, fully equipped catadioptric astronomical telescope available today. The C90 Astro is ideal for serious lunar and planetary work, casual viewing on trips or vacations where space is at a premium, solar eclipse expeditions, etc. Complete with motor drive built into the base for automatic tracking, it is also capable of taking beautiful astrophotographs. A "tripod mounting block" attached to the bottom of the telescope tube permits the tube to be dismounted from the astronomical fork mount, and mounted on a photo tripod for use as a terrestrial spotter or a 1000mm telephoto camera lens (with optional accessories) — great for nature studies!

Basic kit includes f/11 telescope tube assembly (90mmA, 1000mmF); lens shade; 5x24mm finderscope; .96" star diagonal; 30mm (33x) .96" fully coated Kellner eyepiece; 18mm (56x) .96" fully coated Kellner eyepiece; counterweight; single arm astronomical fork mount, with graduated setting circles, manual positioning controls and clutches on both axes of motion; 115 Vac synchronous motor drive; power cord; table top equatorial tripod legs, adjustable for latitude; dust covers for optical apertures; foam lined carrying case; instructions; limited lifetime warranty.

C90 Astro (List: $1,300.00) $799.95

NEW! Electronic Digital Setting "Circles" for C8's!
Digi-Circles .... (List: $ 790) .... Call

CompuStar



Shown: Celestron's CompuStar C8

CompuStar is the most extraordinary telescope system ever made commercially available — it is also among the most complex and costly. If you would like further information before making a decision, please call, or send $10 ($15 foreign), *cash or check only*, for our:

Introduction to CompuStar

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SuperDlx 14x	**14x 80mm, SuperDlx Giant, ..**	**MultiCoated, PorroBino**	**.. ($850.00)**	**.. $499.95**
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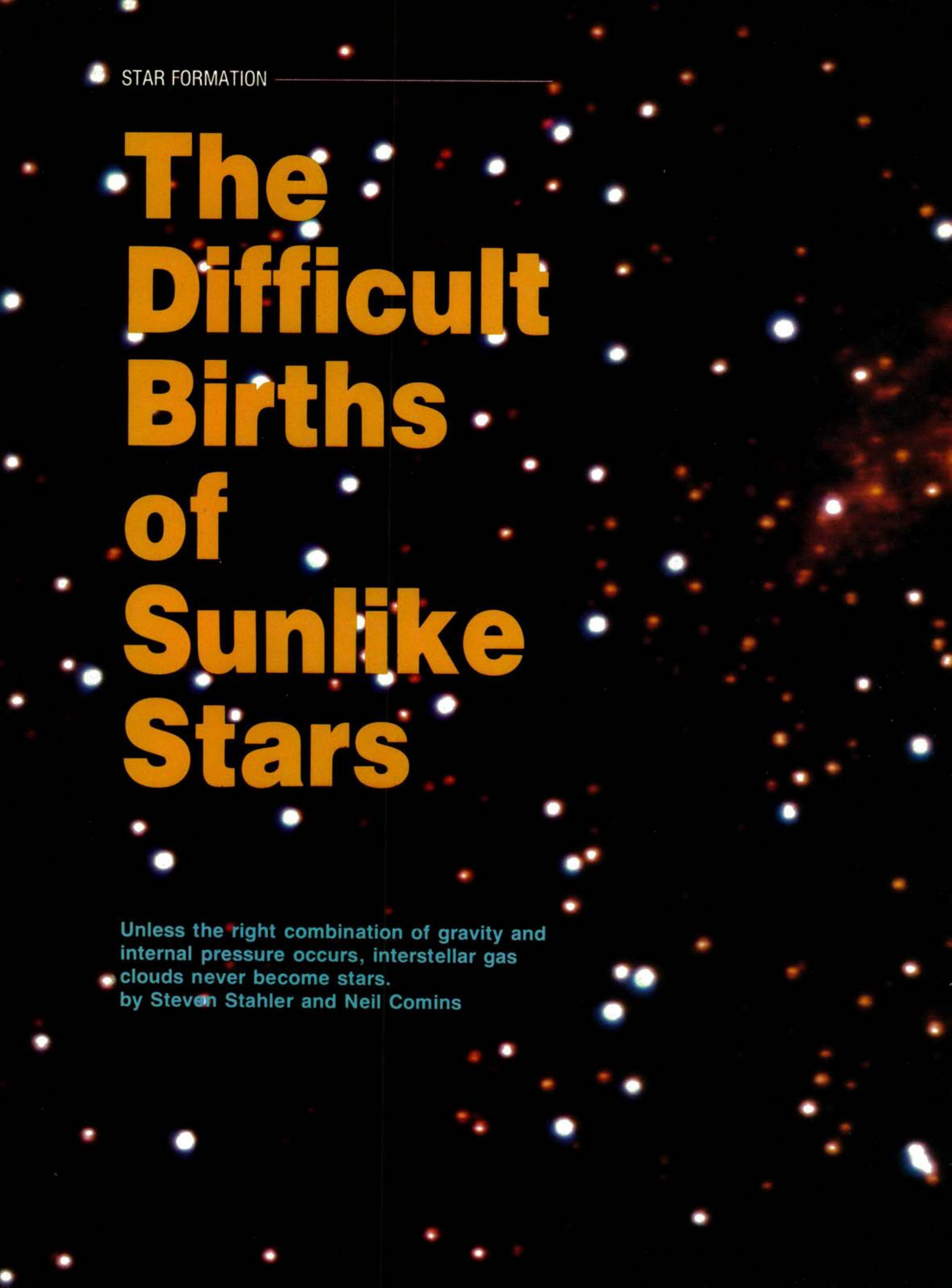
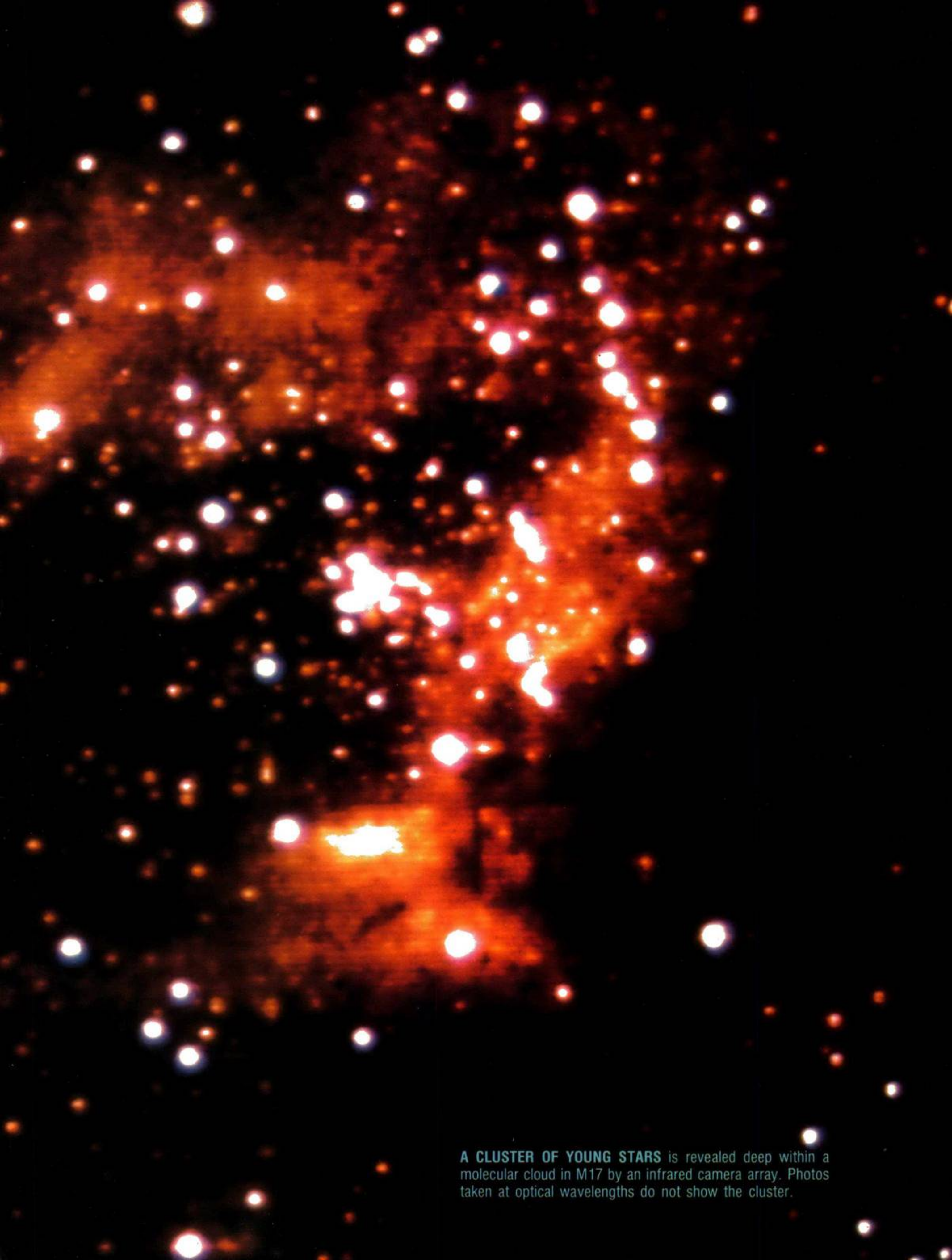


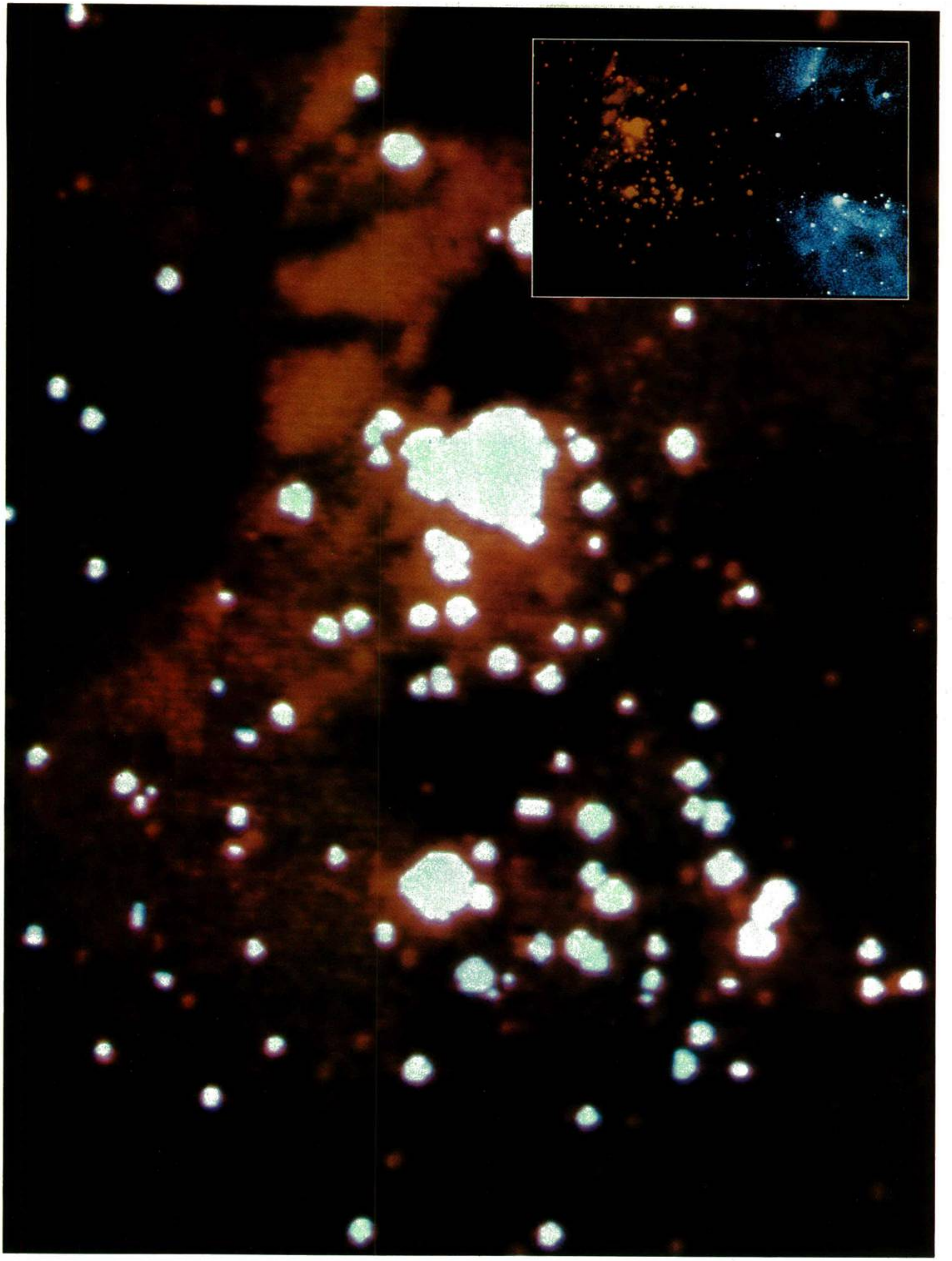
The Difficult Births of Sunlike Stars

Unless the right combination of gravity and internal pressure occurs, interstellar gas clouds never become stars.

by Steven Stahler and Neil Comins



A CLUSTER OF YOUNG STARS is revealed deep within a molecular cloud in M17 by an infrared camera array. Photos taken at optical wavelengths do not show the cluster.

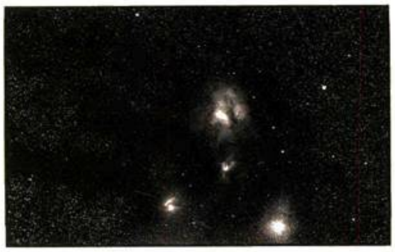


Over 4.5 billion years ago a small region deep inside an enormous cloud of interstellar gas and dust, located in an outer spiral arm of the Milky Way, gradually contracted until it became gravitationally unstable. When the density in this region of the cloud became great enough to allow gravity to overcome all other forces acting on it, the region collapsed. Materials swirled inward, condensed, heated up, radiated energy, and eventually settled down to form the Sun and our solar system.

What properties did that original unstable region have when it began to shrink? Astronomers know it rotated, because its angular momentum manifests itself today mostly in the orbital motions of the planets. But that alone cannot help us answer even the most fundamental questions we have about how stars like the Sun form. To find out more, astronomers are studying similar collapsing regions of interstellar gas and dust in the Milky Way known as cold cores, which are even now in the process of becoming solar-type stars.

Astronomers want to answer three specific questions: What qualities do these cold cores have that allow stars like the Sun to form from them? What exactly happens during the collapse process? And how do newly formed stars evolve?

Because of breakthroughs in stellar evolution theory and greatly enhanced observations provided by radio and infrared telescopes, the pace of discovery has accelerated rapidly within the past fifteen years. Today star-formation research constitutes one of the most exciting and fruitful collaborations between theory and observation in astronomy.



DUST BLOTS OUT STARS in this region of the southern Milky Way. These clouds contain molecular hydrogen, the prime star-forming ingredient.

The belief that stars formed out of collapsing interstellar gas and dust clouds originated in the eighteenth century with Immanuel Kant and Pierre Simon, the Marquis de Laplace. Kant asserted that the solar system initially consisted of a "universal diffusion of primitive matter of all the bodies in space" and that gravity squeezed this diffuse matter into both the Sun and an orbiting gaseous disk that later became the planets. Laplace, however, thought that the planets formed from a series of rotating rings expelled from the equator of the primitive, contracting Sun. Since this early work, gravitational condensation has formed the basis of virtually all accounts of stellar origin.

Until our century, however, astronomers had not identified any interstellar gas or dust. Once the building blocks for stars were found — interstellar gas was identified in 1903 by the German astronomer Johannes Hartmann, and interstellar dust was detected in 1930 by the Swiss-American astronomer Robert Trumpler — it became apparent that star formation did not just occur once, billions of years ago, but is happening today in the Milky Way and in every other spiral galaxy.

A Gathering of Molecular Clouds

To understand how solar-type stars form, we must understand the parent clouds of these stars. Interstellar clouds form out of the gas and dust emanating from old giant stars and from the debris blasted free in stellar explosions such as supernovae. As this gas moves through the Galaxy, it slows down and eventually combines with other stellar remnant material to form clouds.

The gas in these clouds, like most matter in the universe, is primarily composed of the simplest element, hydrogen. Hydrogen exists in three main forms: neutral, ionized, and molecular. Neutral hydrogen, denoted HI, is the most abundant form of hydrogen in the universe and consists of a single electron in orbit around a nucleus, which is a proton. Ionized hydrogen, denoted HII, results when the electron of a neutral hydrogen atom is stripped from the nucleus. And molecular hydrogen, H_2, occurs when two hydrogen atoms combine.

Certain interstellar clouds can form stars; others cannot. It depends primarily on the internal temperature and density and on the radiation impinging on that cloud. For example, the gas surrounding very hot, massive stars, which emit copious amounts of ultraviolet radiation, is fully ionized. These "HII regions" are much too hot to condense into stars, as are the less dense HI clouds commonly found far from the luminous sources. The rapid, random motions of the atoms within these clouds prevent gravity from contracting the clouds into stars. The only clouds both cold enough and dense enough to potentially form stars are those of molecular hydrogen.

Molecular hydrogen is found in many regions of our Galaxy in the form of clumpy, irregular molecular cloud complexes. These complexes measure several hundred light-years across and are the largest individual objects in the Milky Way. They are too cold to emit significant visible light and they appear in photographs as dark patches that obscure the stars behind them. This interstellar obscuration is due to opaque dust grains.

Astronomers theorize that these molecular clouds form continually from condensing HI clouds. At sufficiently high densities the hydrogen atoms inside the HI clouds collect on the surfaces of the dust grains and remain there long enough to bond into molecular hydrogen pairs. These H_2 molecules may then leave the grain surfaces and thereafter be shielded by the high density of the surrounding gas and dust from any destructive interstellar radiation that would again separate them.

The dust grains themselves, which play an important role in this and other aspects of star formation, were created by previous stellar generations. Dust grains are formed in the outer atmospheres of red giants and are expelled by the prodigious stellar winds that signal the deaths of these stars.

Still, we can't learn much about molecular clouds when we see them only as silhouettes! What *positive* evidence is there for molecular clouds? Today astronomers actually "see" these clouds with radio and infrared telescopes. One common technique is to observe the radio emission from carbon monoxide (CO).

DARK "FINGERS" extending across NGC 2024 are probably regions of high molecular density. The inset shows optical and infrared comparisons.

This molecule exists in trace amounts in the clouds but is a strong radio emitter, whereas the more copious H_2 is not.

Using CO and other molecules, radio maps of remarkable detail have been made of many cloud complexes. Such maps reveal the presence of high-density "knots" of gas embedded deep within the complexes. These knots, or cold cores, which are only a few tenths of a light-year in size, are the sites of most star formation.

But astronomers did not realize there was a connection between cold cores and forming stars until these radio maps were combined with optical images. The correspondence showed that cores (detected by radio) and young stars are frequently near one another in the sky. The connection was recently confirmed by infrared observations. Photographs taken by the *Infrared Astronomical Satellite* show that many cold cores contain infrared sources. Stars that have just formed from cold cores should indeed shine in infrared light.

Cloud Collapse

Observations have identified the properties of clouds that form stars. Now astronomers can study *how* they form. Consider for a moment a generic interstellar cloud, either an isolated entity or a piece of a larger system of clouds. Whether or not star formation occurs in this cloud depends critically on the balance between two forces. The first is the inward force of gravity, which binds everything together and which leads inevitably to collapse if it is unopposed. The second force is the outward push of thermal pressure, which is due to the random motion of atoms and molecules within the cloud. Aiding thermal pressure in resisting collapse is the cloud's magnetic field. Although the typical magnetic field in a cold core is tiny — less than 1/10,000th that of Earth's magnetic field — this field temporarily exerts an outward pressure on the gas. However, the effect of the magnetic pressure eventually decreases as the density of the gas increases.

THE VIOLENT OUTFLOW from pre-main-sequence stars shot out this string of excited gas from a dark globule.

Gravity and thermal pressure work in kind of a push-pull manner. When the thermal pressure inside a cloud exceeds the cloud's gravity, the cloud dissipates; conversely, when gravity dominates over thermal pressure, the cloud collapses. This much is obvious, but it has taken detailed calculations to reveal how sensitively the cloud's evolution depends on the relative strengths of thermal pressure and gravity after the cloud's collapse.

To understand the delicate balance involved, consider first a cloud that is so cold its thermal pressure is negligible. Once such a cloud starts to collapse, the gas begins to clump because of the collision of opposing streams of infalling gas. If the gas is cold enough, the clumps will also be too cold for thermal pressure to blow them apart. They rapidly accrete other nearby gas clumps, thereby increasing in size. Once the mass of these clumps becomes large enough, the internal clumps themselves collapse.

This process by which cold clouds break apart into smaller cloudlets — collapse inside collapse — is known as fragmentation. If the cloudlets are cold enough, they undergo the same process of internal clumping: collapse inside collapse inside collapse. This cascade of fragmentation finally halts when the density in the fragments becomes so high that the fragments heat up and the resulting thermal pressure stops further contraction. However, calculations show that with any physically reasonable initial cloud temperature, the final fragment densities and masses are far below the typical stellar values. Thus a cloud with very low initial pressure does not directly form stars.

What condition must exist, then, for stars like the Sun to form? Calculations have shown that fragmentation shouldn't occur when the cloud's initial outward thermal pressure is only *slightly* less than the inward force of gravity. Moreover, observations reveal that this condition is just what exists in cold cores. When a cold core begins contracting, its internal density and pressure naturally begin to rise. However, the pressure doesn't grow large enough to stop the contraction, because the prompt radiation of excess heat keeps the cloud temperature very low. This kind of cooling, known as molecular cooling, is accomplished by radio emission from various molecules. It is this same radio emission that enables us to "see" the cold cores and to map their positions in the sky.

One of the major advances in star-formation theory in recent years is the demonstration, largely through computer simulations, that a cloud collapsing under these conditions doesn't fragment. This finding fits neatly with radio and infrared observations that show stars form singly or in pairs from individual cold cores of relatively low mass and that such cores never give birth to a vast multitude of stars.

So why is this big news in astronomy? For many years astronomers thought that because gravity dominates in warm, high-pressure clouds, the contraction would proceed much as described above even for the very cold, low-pressure clouds. The conventional theory begins with a large, many solar-mass, contracting cloud that fragments, and the fragments themselves break apart. The final fragments, stopped from further fragmenting by increased internal pressure, become the stars in this scenario.

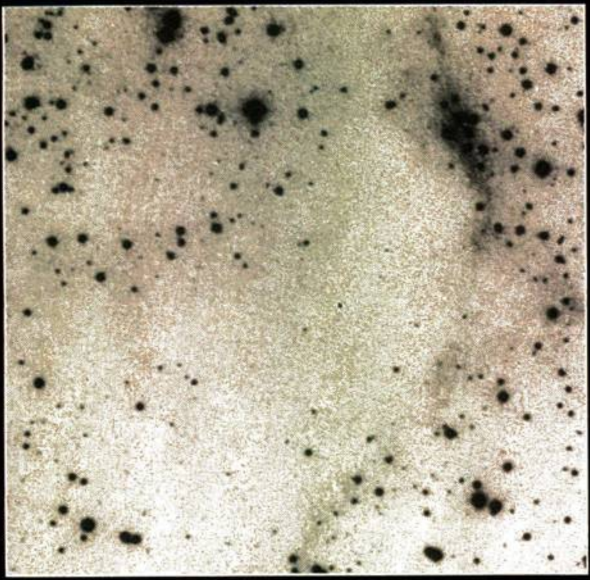
One still finds this "hierarchical fragmentation" scenario in popular accounts of star formation. However, this process cannot produce stars of realistic mass and density. The end fragments are always too small to begin nuclear burning.

The true dynamical evolution of a collapsing cloud with appreciable internal pressure is known as "nonhomologous collapse." This term refers to the fact that the cloud does not contract at a uniform rate throughout the cloud's volume. The density near the center of a cloud undergoing nonhomologous collapse rises much more rapidly than the density in the outer region: gravity wins out and the cloud collapses *from the inside out* like a cave-in. This discovery was an important advance in understanding how stars form.

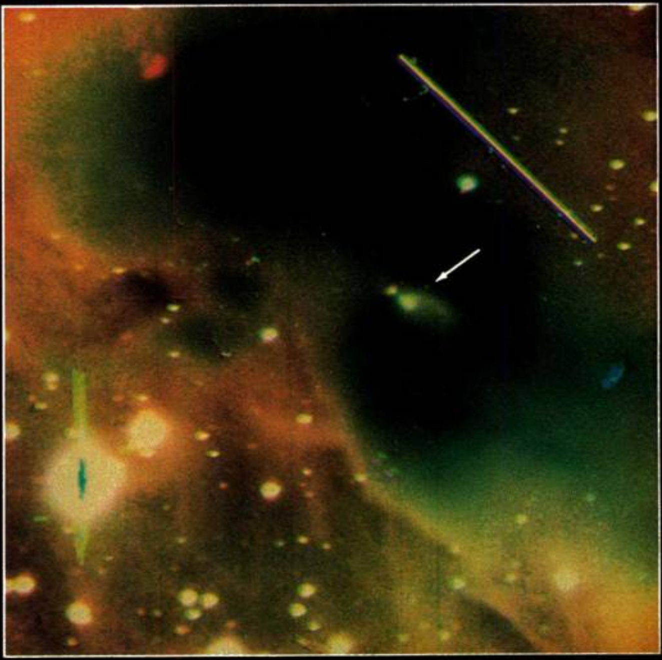
Nonhomologous Collapse — Protostars

Only interstellar molecular clouds in which gravity slightly dominates over thermal pressure form stars. Ini-

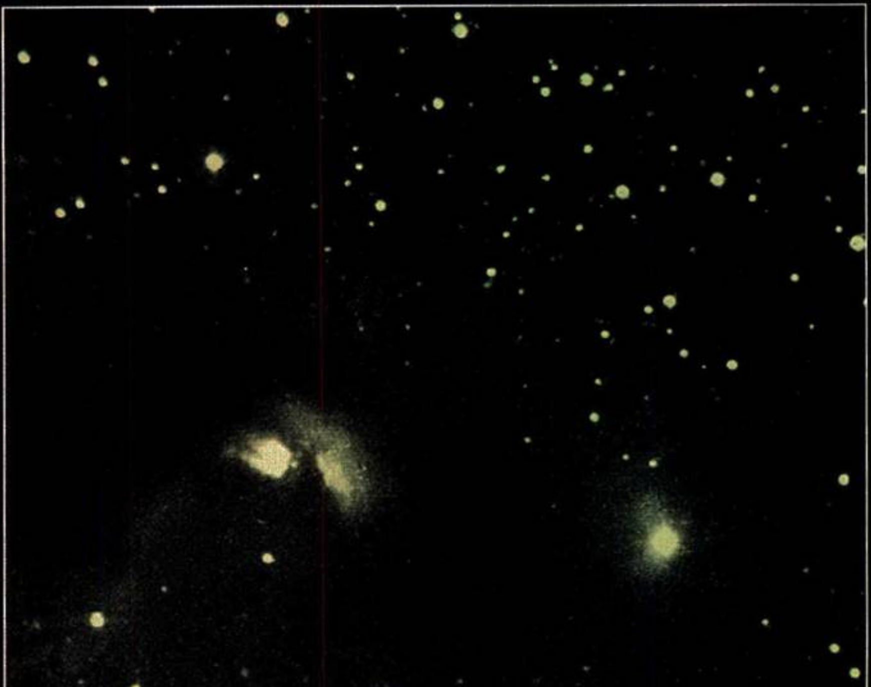
Young Stars Break through the Clouds



HIDDEN AWAY in the dense, dusty core of the dark nebula Barnard 35 is a star like the Sun. The location of the star (indicated by cross hairs) was revealed by the radiation of ammonia molecules associated with the molecular cloud.

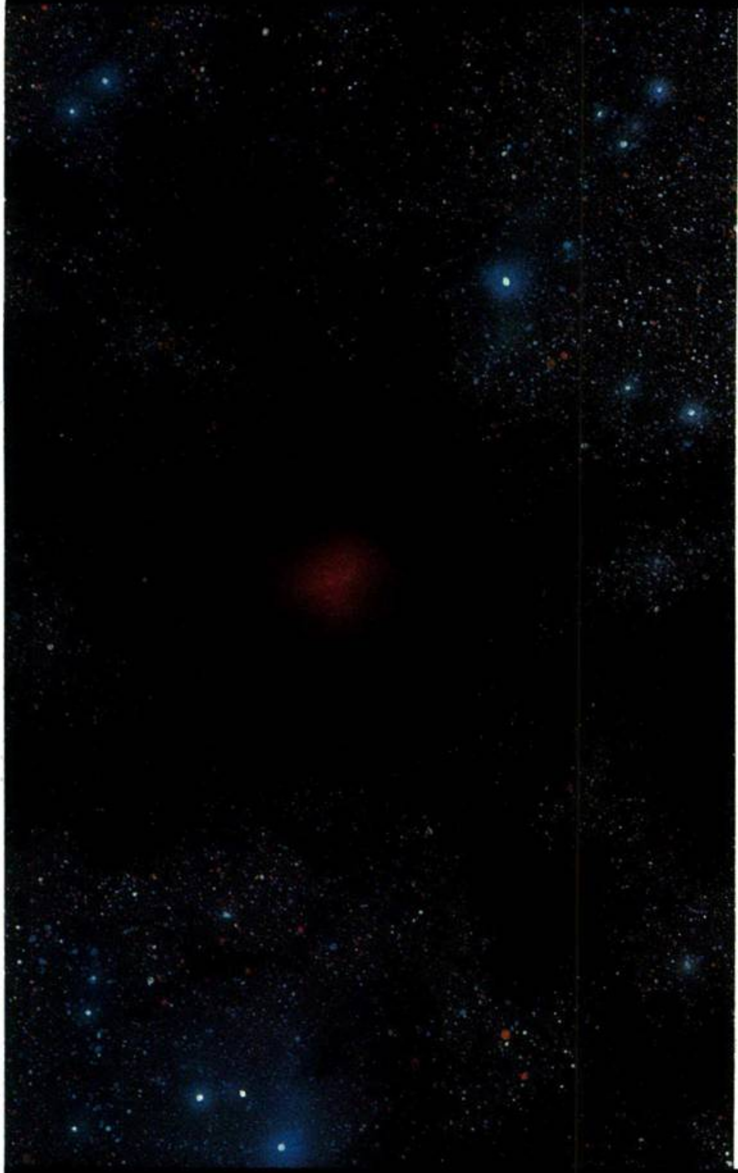


JUST PEEKING THROUGH the dense nebula Lynds 1152, a Sunlike star (arrow) casts off its surrounding shroud of obscuring dust.

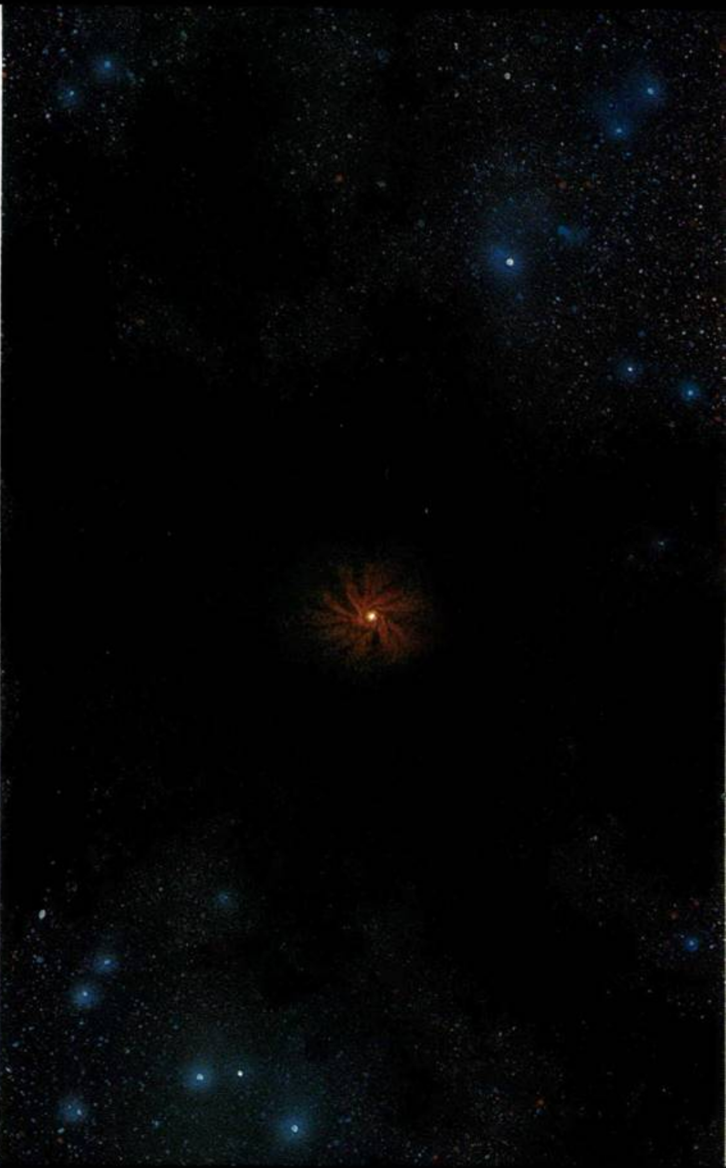


SHINING THROUGH a clearing in its veil of dust, the young star at left center in this CCD image looks very much like our Sun may have looked 4.5 billion years ago.

Inside-Out Star Formation



COLD CORES are the seed pods of Sunlike stars. Here a cold core a few tenths of a light-year across harbors the beginnings of a new star. The density of the molecular hydrogen gas at the center of this core has reached the point where gravity is causing the gas to fall inward and the internal temperature to rise.



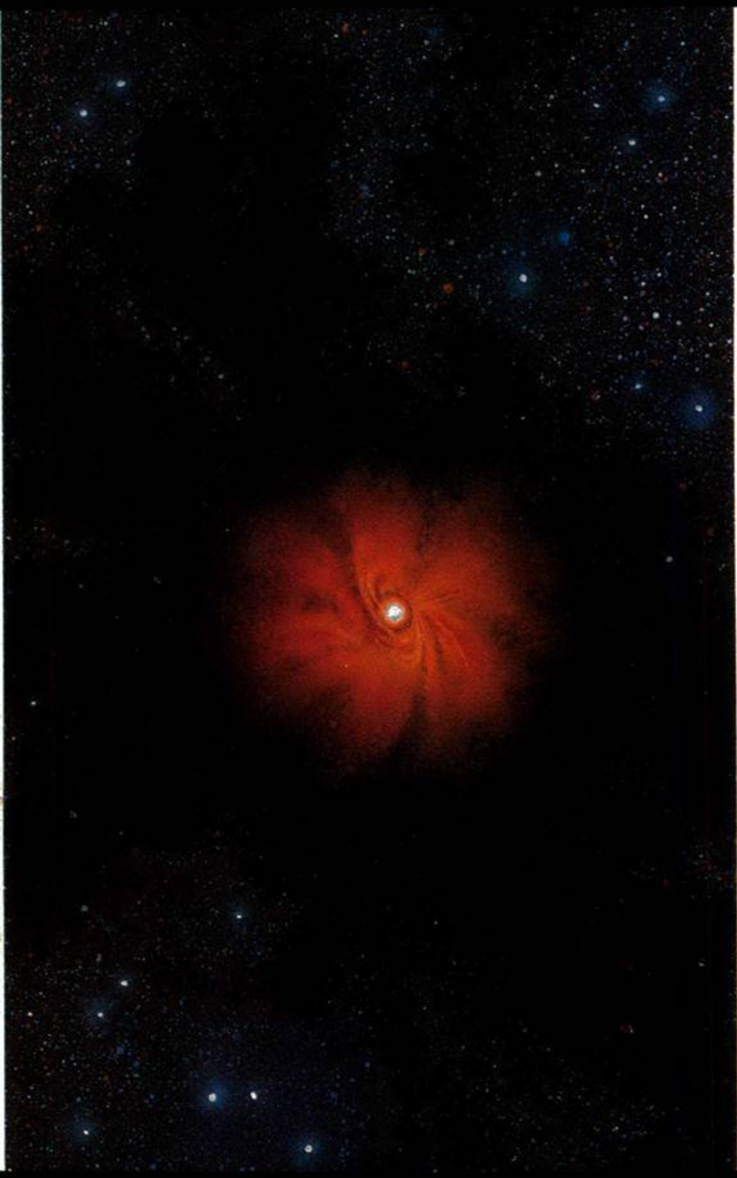
FREE-FALLING GAS collides at the center of the cloud, generating enormous heat and pressure. Soon the central part of the cloud forms a dense hydrostatic core in which gravity and pressure reach equilibrium. This halts the overall collapse but doesn't fragment the cloud. The core's light is reddened by dust particles.

tially the gravitational contraction of a molecular cloud is very slow because of the outward force of the cloud's thermal pressure. Because of the molecular cooling, the cloud's density and pressure increase slowly, with the build-up occurring mostly in the cloud's central region. As the density in the center rises, the force of gravity in that part of the cloud *gradually* becomes much greater than the pressure. Now the stage is set for true gravitational collapse.

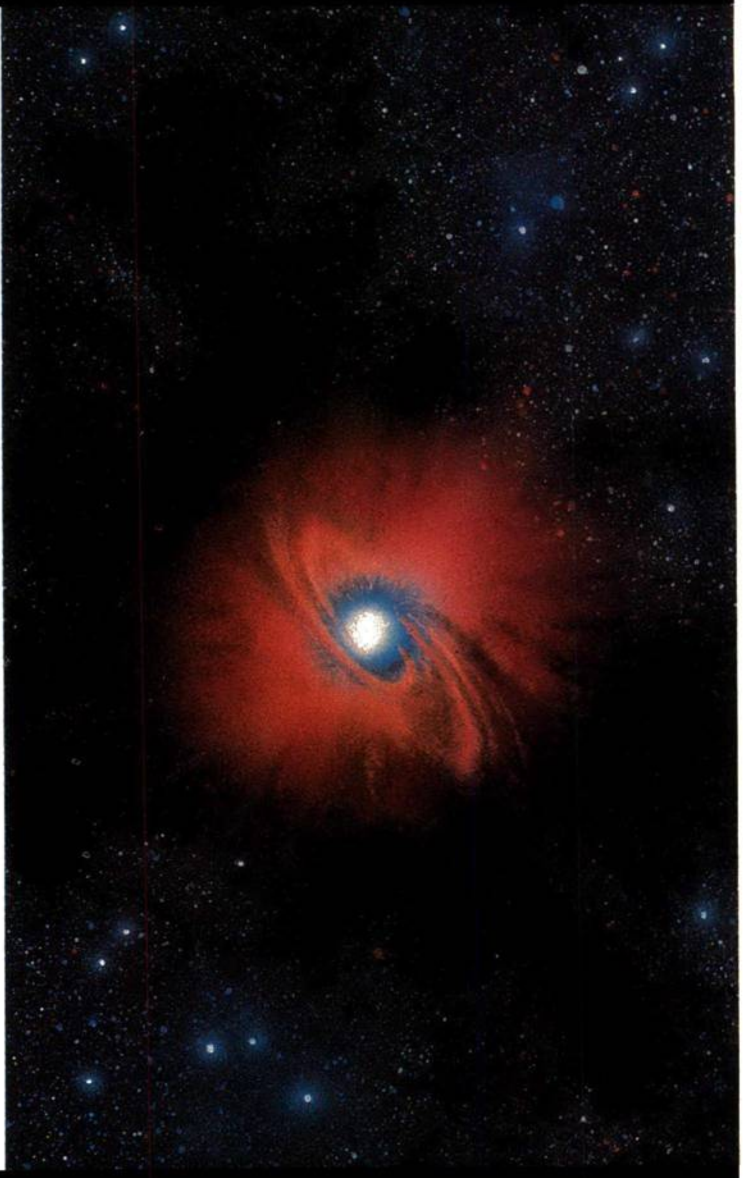
The cloud's interior density reaches a point where gravity dominates over thermal pressure and gas in the innermost region begins to fall freely toward the center. Rushing streams of gas collide with one another, generating enormous heat and pressure. Soon the central region forms a dense hydrostatic core, in which thermal pressure and gravity actually come into balance, halting the collapse (and not fragmenting). During the collapse of the central region the outer reaches of the cloud have not yet begun their own free fall but are still undergoing the original slow contraction. The region of free-falling gas, in fact, rushes outward from the hydrostatic core at the speed of sound.

This inside-out process is the essence of nonhomologous collapse. The central hydrostatic core and the diffuse envelope falling freely onto the core make up the "protostar." The protostar phase is the first stage in the life of any star.

The source of a protostar's luminosity is derived from the kinetic energy of the free-falling gas in the envelope, *not* from the nuclear fusion process that powers the



A STRONG SHOCK FRONT between the hydrostatic core and the infalling gas represents the primary energy source for the young protostar. The shock front arises from gas crashing on the surface of the hydrostatic core at hypersonic speed. The shocked gas rapidly cools and amasses on the core's surface.



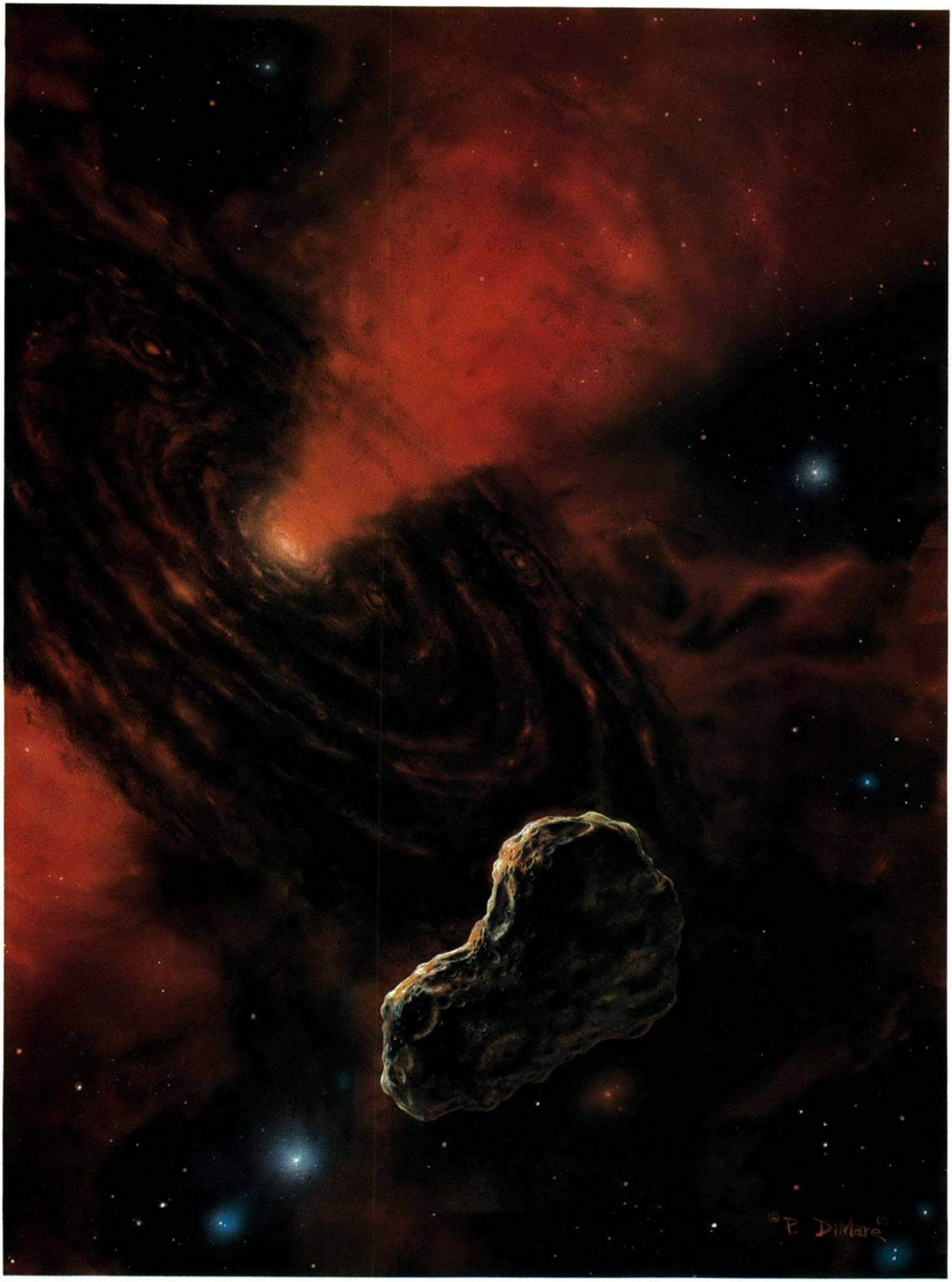
THE FREE-FALL REGION continues expanding as the hydrostatic core pulls in more mass from the parent cloud. The increased mass causes further gravitational contraction, which leads to higher thermal pressure in the core. This slows the collapse almost to a halt. The star now enters the pre-main sequence phase.

Sun and other mature stars. The free-falling gas, traveling many times faster than the speed of sound, crashes onto the surface of the hydrostatic core. Like a speeding car that hits a brick wall, the infalling gas comes to an abrupt halt, which creates a tremendous shock wave that rebounds from the hydrostatic core's surface. This violent process causes the high-temperature, shocked gas at the core's surface to radiate a large amount of energy. A hydrostatic core with the mass of the Sun emits about ten times as much energy as the Sun

The strong emission of radiation caused by the shock rapidly cools the gas that strikes the core. This cooler gas then settles onto the core surface at a relatively low speed. The hydrostatic core pulls in the mass of its parent cloud by this accretion process through the shock front. If we could see the protostar at this stage, its surface radiation would be like that of a normal star.

However, the radiation leaving the core surface must fight its way through massive amounts of dust in the protostar's envelope. The photons are absorbed and reemitted by the dust grains so many times during their outward journey that the radiation of the photons shifts toward the red end of the spectrum. In fact, the amount of dust is so great that the photons that ultimately escape the cloud have frequencies in the infrared.

As a consequence, protostars are invisible at optical wavelengths. They appear as infrared sources inside regions of molecular gas. The *Infrared Astronomical Satellite* observations, which show point infrared sources inside cold cores, are in striking agreement with this the-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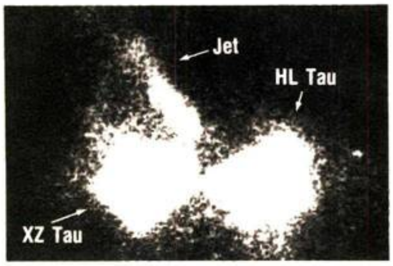
oretical prediction.

As the material in the envelope streams towards the central core, its temperature increases because the materials is absorbing energy from the shock-emitted radiation. When the envelope's temperature reaches about 2000 kelvins, the dust grains in the envelope evaporate. The envelope becomes dust-free, and the stellar radiation easily traverses this region, known as the opacity gap. Subsequent radiation is then only reddened by dust absorption farther out in the colder regions of the envelope.

Our model of the protostar phase breaks down if the mass of the hydrostatic core becomes very large. Massive cores begin the hydrogen fusion process even while they are accreting gas from the infalling envelope. The added luminosity from fusion is so high that radiation pressure on the dust grains in the envelope blows back the accreting gas, choking off the growth of the hydrostatic core. Current theoretical calculations indicate that this happens for core masses as low as five solar masses. Because stars of this mass certainly exist, their early evolution follows a very different path than we present here for low-mass stars.



A JET OF HYDROGEN GAS expelled by the star HL Tauri may be powered by the star's strong stellar wind.

The Slow Turn-On

Once the protostar's hydrostatic core has pulled in its envelope of dust and gas, the shock front at its surface disappears. This does not mean, however, that the core no longer emits energy. Because the core is still not burning nuclear fuel at its center, its own gravity causes it to contract. The contraction leads to higher pressure and temperature in the deep interior, and this additional heat eventually escapes from the surface as radiation. The high thermal pressure inside the hydrostatic core prevents gravity from creating a free-fall collapse, and the star now undergoes a much slower contraction with internal motions well under the speed of sound. This quasi-static contraction marks the star's pre-main-sequence phase, the phase that precedes the star's entry into its prime hydrogen-burning period. Our Sun took 10 million years to contract in this manner to its present size after its protostar phase, which lasted about 100,000 years.

The internal structure of the pre-main-sequence star is still quite different from that of mature stars. The energy, generated in the star's turbulent interior by gravitational contraction, boils upwards via thermal convection. Giant blobs of gas, made buoyant by their internal heat, rise toward the stellar surface. As the blobs rise, they enlarge until they burst and radiate their heat to the surrounding gas. The cool material that is left then sinks quickly down, ready to receive another supply of heat from the lower regions.

Everyone has seen convection at work in a pot of boiling water. Indeed, thermal convection is always created whenever a gas or liquid experiences too sharp a drop in temperature while under the influence of gravity. For water on the stove the temperature drop is created by heating from below. In a pre-main-sequence star the temperature drop stems from rapid cooling at the stellar surface. This cooling and the ensuing convection occur as soon as the protostellar accretion shock disappears.

Because pre-main-sequence stars are no longer surrounded by a dusty envelope, their radiation is visible at optical wavelengths. Indeed, astronomers believe that the observed class of stars known as T Tauri stars represents this phase of evolution. These stars are always found near molecular clouds and were suspected of being extremely young objects long before the advent of modern star-formation theory. The pre-main-sequence phase of stars is so brief, relative to the total lifespan of stars, that only a few thousand of these stars have been cataloged. Nevertheless, when the radii of the youngest T Tauri stars are calculated from observed luminosities and surface temperatures, the results are in agreement with the predictions of protostar and pre-main-sequence theory.

On the other hand, most of the detailed properties of T Tauri stars — particularly the variability, radiation, and energy outbursts of these stars — are not understood. These stars are irregular variables; their luminosity fluctuates on timescales from hours to months. It is possible that this variability is related to the turbulent convection below the surface, but the connection is not well understood. In addition, their spectra reveal copious amounts of infrared and ultraviolet radiation. Finally, there is much exciting evidence in recent years for powerful jets of gas streaming away from the surface of the youngest T Tauri stars. It is likely that these jets help to clear away any material from the original parent cloud that still surrounds the stars. However, current theoretical calculations provide no clue about how such energetic outbursts arise.

On to the Main Sequence

We now come to the last episode in our saga, the stage at which the star finally begins fusing hydrogen into helium. A star contracting in its pre-main-sequence phase is continually losing energy in the form of radiation. Nevertheless, its interior temperature actually increases in the course of contraction. This apparent paradox is caused by the ability of the star's own gravity to squeeze the star to higher densities and temperatures faster than the star can radiate energy away.

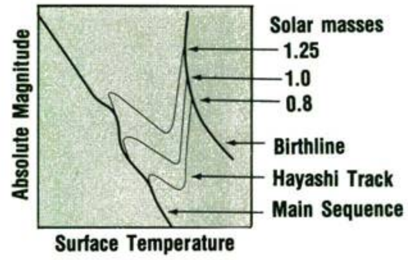
Once the star's central temperature reaches 10 million kelvins, thermonuclear fusion of hydrogen into helium begins in the central region. Each fusion event gives off high-energy photons (gamma rays) that, upon absorption by the surrounding gas, create a high thermal pressure. As a result, the star's gravitational contraction is brought to a halt for as long as this hydrogen "burning" in the center continues. Thus, the two forces — gravity and thermal pressure — balance out and the star enters a fairly stable stage where it will remain for most of its life. In the Sun's case this hydrogen-burning era will last 10 billion years from the time fusion began about 4.5 billion years ago. Astronomers refer to this

A YOUNG, SUNLIKE STAR clears away its cocoon of gas and dust within its parent molecular cloud. Orbiting the star is a disk of material that may spawn planets.

hydrogen-burning era as the main sequence. Clearly the main-sequence phase of a star's lifetime is far longer than the early stages.

Astronomers picture the entire evolution of a star in terms of the Hertzsprung-Russell (H-R) diagram. This diagram, which relates a star's luminosity (emitted energy per unit of time) to the star's surface temperature, provides an excellent way of tracking changes in a star's observable features over the star's lifetime.

The chief means used to test the theory of stellar evolution is comparing the theoretical and observed positions of stars on the H-R diagram. We find that about 90 percent of all observed stars fall along a narrow curve in the diagram that corresponds to the main sequence. Theory predicts that these stars will all be hydrogen-burning stars. Each point along the main sequence, therefore, corresponds to a single stellar mass; the higher the mass, the hotter and more luminous the star. Because the luminosity and surface temperature of a main-sequence star change only slightly as the star consumes hydrogen, the point representing that star in the diagram also moves very little over billions of years. On the other hand, the star moves relatively rapidly in the diagram during both early and late phases.



A PROTOSTAR on the H-R diagram contracts from the birthline to the main sequence along Hayashi tracks.

A protostar cannot be pictured in a conventional H-R diagram, because its emitted luminosity is not optically visible. However, as soon as the collapse ends and the remnant envelope material clears away, the new pre-main-sequence star has a high enough surface temperature to be placed in the diagram. Theory predicts that stars with masses less than or about equal to that of the Sun initially appear along another curve in the H-R diagram. This curve is known as the "birthline." As the pre-main-sequence star contracts towards the main sequence, its position on the H-R diagram moves downward from the birthline. The path a star takes from its birthline to its place on the main sequence is known as a "Hayashi track," named for the Japanese astrophysicist who first accurately computed the properties of pre-main-sequence stars in the 1960s. If we consider a range of stellar masses, the various Hayashi tracks — all roughly parallel to one another — end at the appropriate points on the main sequence.

Although the birthline and the Hayashi tracks were first predicted theoretically, their existence can be demonstrated by direct observation. We have already mentioned that the T Tauri stars are believed to be undergoing pre-main-sequence contraction. These stars are usually observed in populous clusters, known as T associations, found near giant molecular cloud complexes. By painstakingly observing the spectra of hundreds of stars, astronomers have been able to construct H-R diagrams for a number of the nearest T associations. They find that the stars in these associations indeed lie above the main sequence. Moreover, in associations that were already suspected of being the youngest, because of the large amount of nearby molecular gas, the most luminous T Tauri stars lie along a definite upper boundary in the H-R diagram. Recently astronomers have shown that this observed boundary corresponds remarkably well with the theoretically predicted birthline, which shows how well the H-R diagram meshes theory and observation.

Remaining Mysteries

Many other aspects of star formation remain to be understood, particularly how planet formation proceeds from star formation. Astronomers believe the disks of gas and dust recently discovered around a number of young stars, including several T Tauri stars, may be precursors to planets. This exciting discovery, however, points to a basic inadequacy of the nonhomologous theory: the neglect of rotation. It's easy to see why a molecular cloud that is rotating as it collapses produces a disk around the central hydrostatic core: for sufficiently fast rotation, material in the outermost portion of the cloud will be rotating so rapidly that by the time it falls a large distance, centrifugal force will keep it from hitting the stellar surface and will force it instead into orbit around the star.

On the other hand, the same theoretical model, which is essentially the one first proposed by Kant, predicts that the surface of the central star will also be rapidly rotating. Observations of T Tauri stars, however, show all the stars rotating very slowly. Apparently, something slows their rotation with extraordinary efficiency. What can this force be?

Many astronomers believe the braking agent is the star's own magnetic field. Specifically, this field is thought to be generated by the combined action of convection and rotation in the subsurface layers. During the protostar phase, magnetic field lines rise from the surface of the rotating hydrostatic core and are trapped in the partially ionized material of the growing circumstellar disk. The field lines become twisted by the stellar rotation, and they in turn transfer rotational energy to the disk. The net effect slows down the hydrostatic core and simultaneously spins up the disk.

The idea of magnetic braking of protostars is attractive, because it is analogous to a similar process known to be occurring in the Sun. However, the magnetic fields in protostars are probably much greater than in the Sun, and the mechanism outlined above has yet to be proved through actual calculations.

In any case, a better understanding of rotating protostars and disk formation will provide, for the first time, reliable initial conditions for theorists struggling to reconstruct the origin of the solar system. It's a long way from diffuse molecular clouds to planets, and many dynamical conditions must be considered. Once these conditions are learned, a vital link will have been forged between two diverse areas of research: the collapse of clouds into stars and the formation of planets. ☐

Steven Stahler is an assistant professor at the Massachusetts Institute of Technology in Cambridge, Massachusetts. Neil Comins is an associate professor in physics and astronomy at the University of Maine. Comins was co-author of the article "How Do Spiral Galaxies Spiral?," which appeared in the December 1987 issue.

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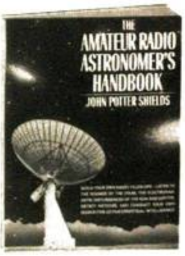
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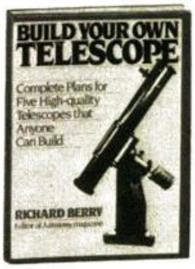
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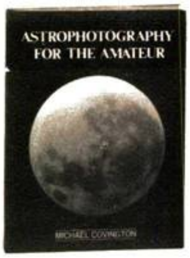
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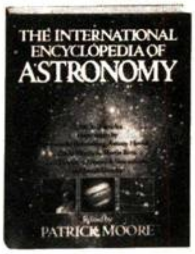
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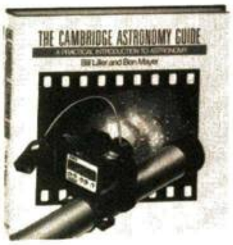
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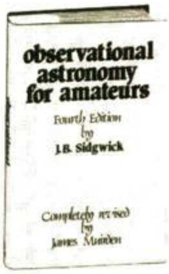
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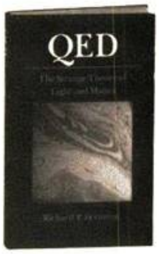

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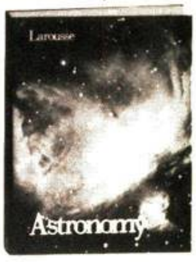
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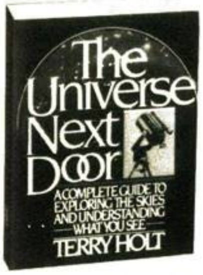
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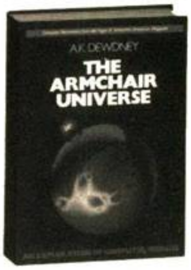
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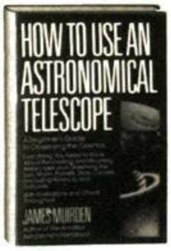
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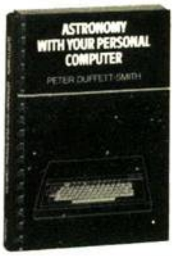
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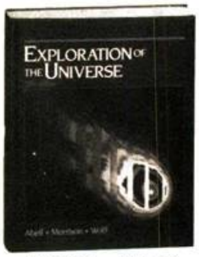
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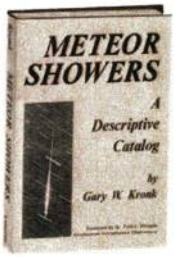
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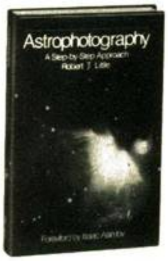
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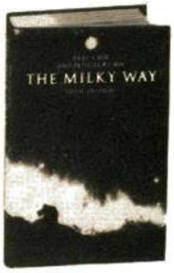
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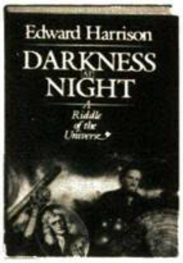
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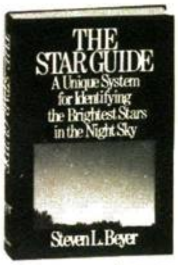
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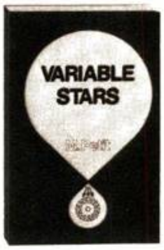
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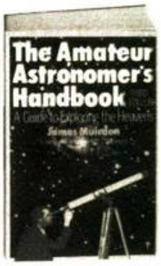
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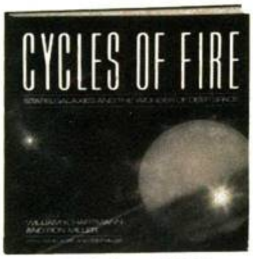
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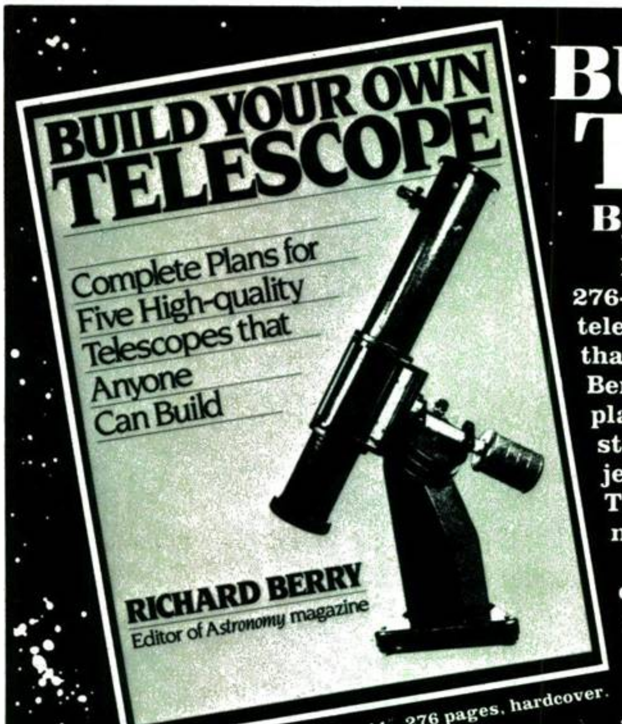
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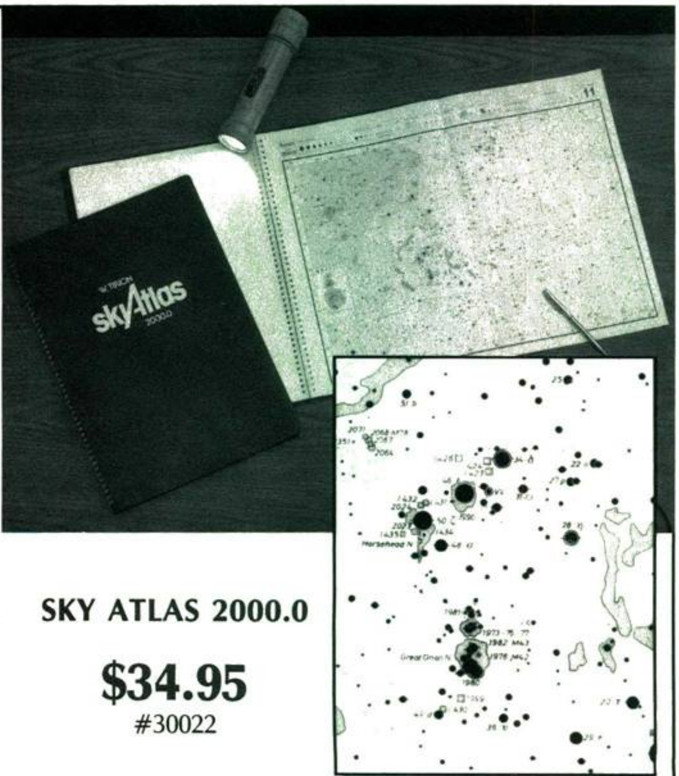

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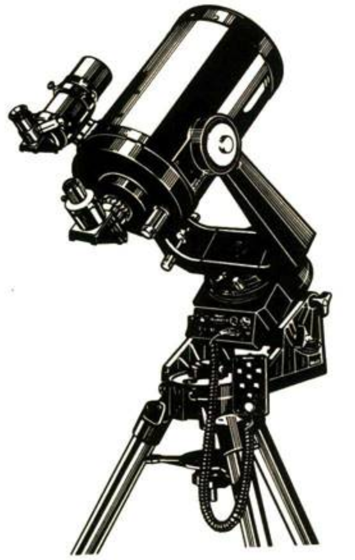

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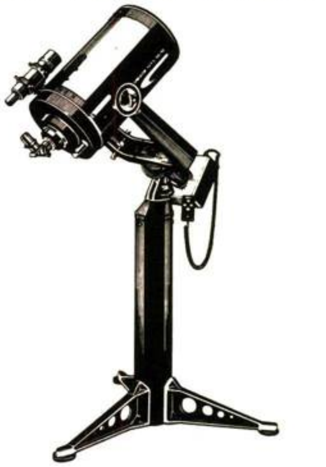

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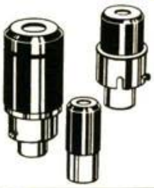

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ASTRONOMY IN OUR

Astronomy was expelled from American schools in 1894, thrown out by the educational reform spirit of the day that promoted practical "education for life." Within a decade astronomy had virtually disappeared from the classroom. The decline was so pervasive that in 1920 W. W. Campbell, director of Lick Observatory, chided U.S. educators for producing a generation of high school graduates that could "tell us all about the lights in our houses, but not one word about the lights in our sky."

The effect of that expulsion still endures. High school graduates today learn less about the lights in the sky than their great-grandparents did one hundred years ago. Science teachers are not trained in the fundamentals of astronomy in college. Textbooks and classroom materials on astronomy are hard to come by.

But there is reason to believe that astronomy is about to rise again. A growing network of educators around the country is providing workshops for teachers. Professional astronomers are developing training programs and materials for elementary and secondary teachers. And the federal government is funding the development of a high school astronomy course.

This resurgence of interest in astronomy is part of the current educational reform movement that calls for improved scientific literacy. With national economic health more and more dependent on technical expertise, a scientifically proficient populace is essential. According to a recent international survey of student achievement in science, U.S. ninth graders placed fifteenth out of the students polled in seventeen countries including Japan, Great Britain, and Canada.

While no one is claiming that the balance of trade will suddenly improve if more students know what the ecliptic is, astronomy advocates do believe the country would benefit from astronomy's ability to engage student interest in a wide range of sciences.

"Astronomy is unique among the sciences," says Jeanne E. Bishop, textbook author and planetarium director for the public schools in Westlake, Ohio, "because so many other disciplines — chemistry, physics, biology, geology — are incorporated in it. Astronomy provides a good understanding of science as a whole."

"I'm not sure anything else would have grabbed my attention in school like astronomy did. I'm a scientist today because of astronomy," says Ken Willcox, a research chemist and vice president of the Astronomical League, the national association of amateur astronomers. "Astronomy is a good way for kids to test their interest in science as a career."

Judging by the low student enrollment in high school science courses, not many kids are currently testing their interest in science. During the last two years of high school the number of students taking science courses drops from one half to one third of the class. Chemistry and physics are taken by only one third of high school students. The scientific literacy of American youth won't be improved if students are not in science classes.

Proponents of astronomy education maintain that many more students would take science in high school if astronomy were one of the choices. Physics is currently taught in 80 percent of the nation's high schools, chemistry in 90 percent, and astronomy in 8 percent.

"Astronomy is the right subject for students who don't elect physics or chemistry in high school," says Philip Sadler, project director of the federally funded high school astronomy curriculum program, Project STAR. "It is a very visual science and it intrigues most students. When it is offered, kids take it. In a way astronomy is a product that fits today's education market."

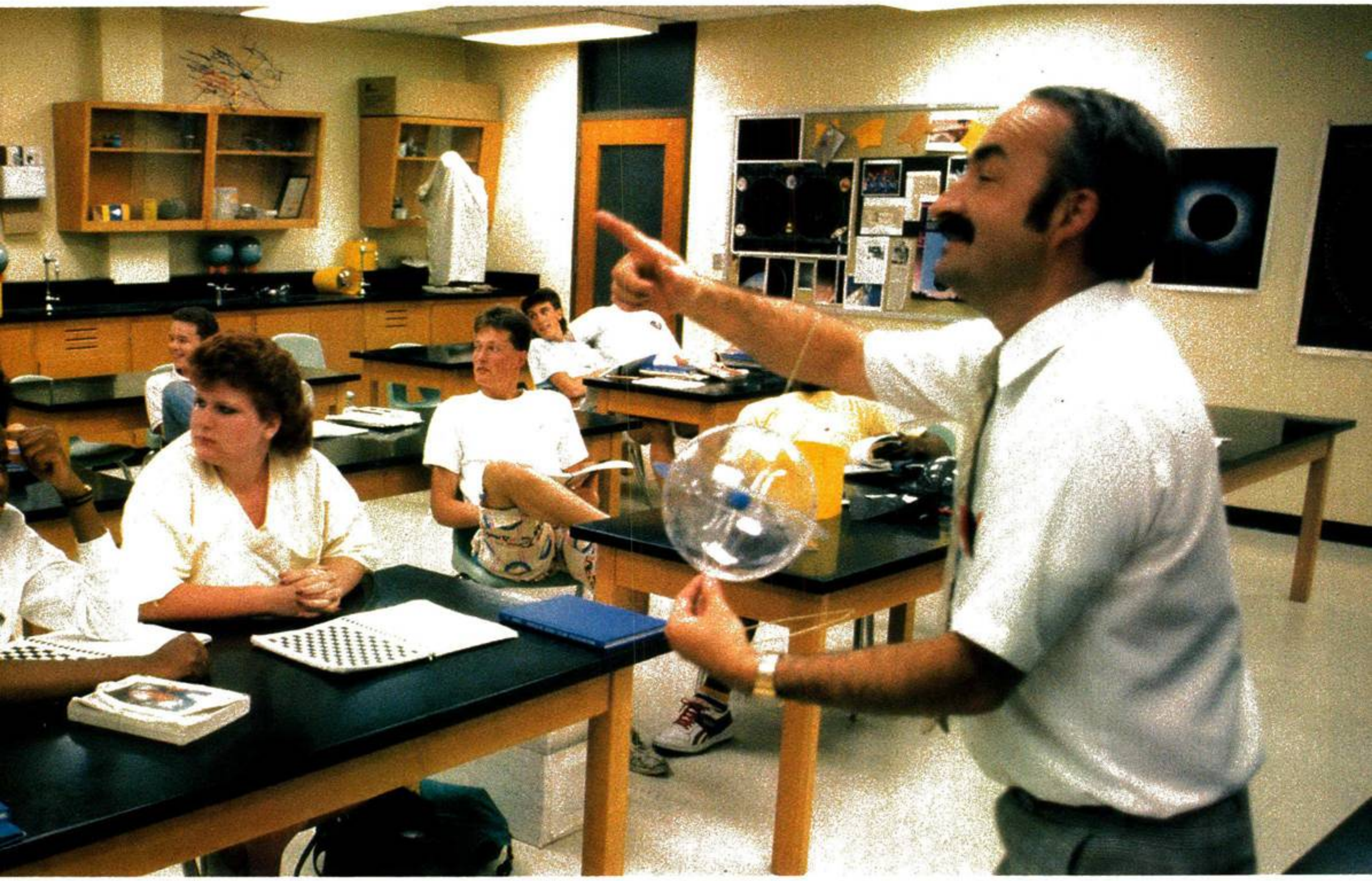
It may be hard for even diehard amateur observers to imagine astronomy ever gaining the status of the big three sciences — biology, chemistry, and physics — in the nation's high schools. These subjects have such an aura of permanence that it somehow feels presumptuous to think another science could join their ranks.

But these sciences did not rise to prominence through some sort of academic natural selection in which the *superior subjects prevailed*. They dominate today because that's what educators wanted to teach in the 1890s. If educators in the 1990s want to teach something else, they can decide to do so.

SCHOOLS

A grassroots movement is getting astronomy back into the classroom.

by Stephen Cole



Prior to 1894, astronomy was widely taught in the United States as part of "natural philosophy." But an influential report on secondary school studies by the National Council of Education put an end to that. The report, produced by a committee of educators led by Harvard University president Charles W. Eliot, sought to standardize high school curricula and college entrance requirements.

The report recommended that physics and chemistry should be required for college admission and that astronomy should not. The report's recommendations were widely adopted, and as a result, astronomy instruction quickly disappeared. From 1895 to 1910 the number of college-bound students who had studied astronomy dropped by 90 percent.

The situation did not improve until the 1950s when the shock of the Soviet *Sputnik* launch brought a surge of interest in science education. Astronomy made some gains as federal funds poured into science curriculum development programs like Harvard Project Physics, which contained some astronomy. The construction of school planetariums was also supported by federal dollars, and hundreds of planetariums sprang up in the 1960s. But when funding for these programs dried up in the 1970s, interest in astronomy also dried up.

Today astronomy can be found in elementary and secondary science curricula, but it is spread very thinly, so thinly that many students leave school without any significant course work in astronomy. Students first encounter astronomy as part of the Earth science curriculum between third and sixth grade. Separate astronomy courses are offered in only 5 percent of U.S. middle schools and in less than 10 percent of high schools.

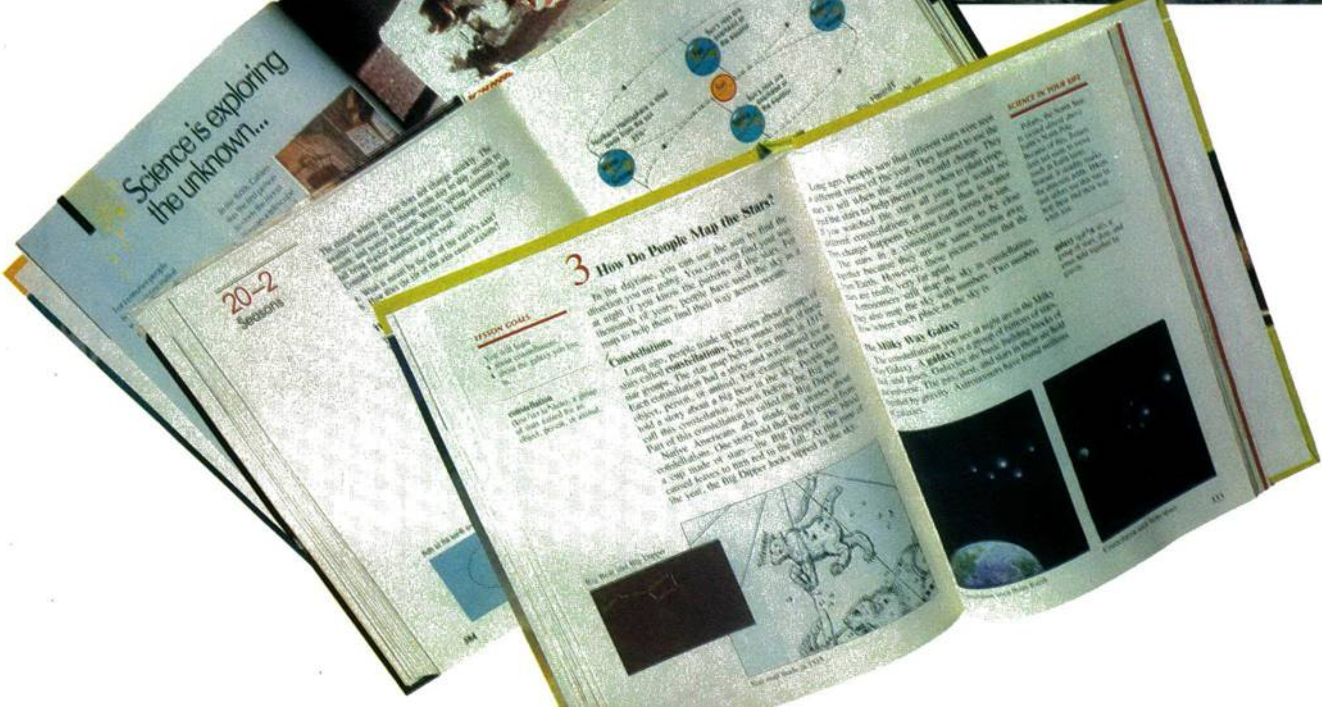
As part of Earth sciences, astronomy shares class time and textbook chapters with geology, meteorology, and oceanography. Although astronomy usually receives one quarter of the year, the astronomy unit often shrinks to as little as two weeks.

Earth science is not, however, like reading, writing, or arithmetic, a subject students will necessarily encounter before they graduate from high school. "It is a neglected science," says Sharon Stroud, past president of the National Earth Science Teachers Association and a science teacher at Widefield High School in Colorado Springs. Recent surveys have found that Earth science is taught at the elementary level in less than half the states

THE ADLER PLANETARIUM

HANDS-ON ASTRONOMY activities like using a telescope and building a pinhole camera to observe a solar eclipse are part of the educational opportunities at Chicago's Adler Planetarium.

ASTRONOMY SHARES PAGES in elementary and middle school Earth science textbooks with geology, meteorology, and oceanography.


Science is exploring the unknown...
20-2
Seasons
3 How Do People Map the Stars?

and that there is no Earth science course offered in 70 percent of U.S. high schools.

If a student does receive instruction in Earth science, he will probably first learn about astronomy as a fourth grader. He will learn about the Sun-Earth-Moon system and seasons, tides, and eclipses; he will be able to name the nine planets. In middle school he will study the planets in more detail, learn about the different types of stars, and begin to think about relative distances in the solar system and the universe. If he takes an Earth science course in high school, he'll study the intricacies of stellar evolution and planetary motion.

An important — and usually memorable — component of astronomy education, especially in the lower grades, is the planetarium. About five hundred school districts in the United States have their own planetariums. Planetariums are also found in most major metropolitan areas. And if neither of those is available, a school can set up an inflatable planetarium in the gym.

"Planetariums have played a major role in improving astronomical literacy," says Jeanne Bishop, former president of the International Planetarium Society. Bishop's involvement with planetariums dates back to the planetarium her father, a university physics professor, built in the family garage when she was growing up.

"You don't get the geocentric picture of what is happening in space anywhere else but in the planetarium," says Bishop. "Without that ability to switch points of view between the geocentric and what's really happening, students grow up with a strange idea of the concept of seasons and lunar phases."

Making that conceptual jump between what a student sees in the sky and what is shown in a textbook diagram can be a very difficult task. Understanding how the Earth's movements affect our view of the sky can be a major stumbling block for students. "I'm amazed at what kids don't know," says Russ Harding, planetarium director for the public schools in Norwalk, Connecticut, and head of the Association of Astronomy Educators. "They often have no idea that there are seasonal changes in the sky, no idea that if you traveled south you'd see a different sky."

According to interviews conducted by Project STAR researchers looking into student preconceptions about astronomy, such conceptual problems are very common. "The misconceptions that students — and even adults — have are so striking and so worrisome that the fundamental focus of our whole project is to try to change some of these," said project director Sadler. Common beliefs include the view that Earth's shadow causes lunar phases, that stars don't move in the sky, and that the planets are fairly close together.

Educators lobbying for wider acceptance of astronomy in our schools have a lot of obstacles to overcome. The historical legacy of the last century has left little time for astronomy in the classroom; misconceptions about astronomical concepts have gained wide circulation. But the hardest problem to overcome may be that today's science teachers lack experience teaching astronomy.

"A lot of Earth science teachers are not qualified to teach Earth science," says Stroud, noting that many Earth science teachers are biology teachers who have been assigned an additional course. Although high school science teachers generally have an undergraduate degree in science — and one third have taken a college astronomy course — middle school science teachers have less training and elementary teachers may have had no science background.

In a National Science Foundation survey of science education released earlier this year, only 15 percent of elementary school teachers reported that they felt very well qualified to teach Earth/space sciences, compared to 27 percent who felt competent in the life sciences.

According to Jeanne Bishop, new teachers are not well trained in astronomy because their college instructors don't have an adequate background in astronomy. "This is a cyclical problem we're still trapped in today. Before the 1890s everyone who taught elementary school or high school had taken courses on natural phenomena. But when high schools from 1900 through 1950 dropped astronomy, these teachers didn't get much background in it."

Astronomy classes are not available to students in 90 percent of U.S. high schools.

The long-term solution to reversing this cycle of astronomical ignorance would have to involve changing the teacher training process, says Bishop, although she acknowledges that this is unlikely. "I'd like to see a course called 'elementary descriptive astronomy' become a college requirement for all teachers, no matter what discipline they specialize in. If the course did nothing more than turn teachers on to the beauty of the subject, astronomy would trickle down through many different disciplines into students' education."

Despite the magnitude of the problem, many astronomy educators are doing what they can at the grassroots level to train teachers in astronomy. "You have to push the educational community into this," says Russ Harding, who, as head of the Association of Astronomy Educators, gives workshops at national teachers' conferences and publishes a newsletter of astronomy activities for teachers at all grade levels. The National Earth Science Teachers Association also offers astronomy workshops at teacher conferences and maintains a state-by-state network of resource people for teachers to contact.

"Teachers are very thirsty for information," says Harding. "But they say they don't have a lot of background in the area, that they don't know where to start." Harding's answer is to give teachers classroom activities that teach solid science but do not require an extensive background in astronomy.

"Many teachers are afraid to teach astronomy because they're worried that their students will know more about it than they do," says Andrew Fraknoi, executive officer of the Astronomical Society of the Pacific, the one hundred-year-old educational organization that has sponsored ten annual teacher workshops.

These workshops have attracted two hundred teachers each year for two days of lectures on astronomical fundamentals as well as the latest research news and demonstrations of classroom activities. This year's workshop, held this summer in conjunction with the society's annual meeting in Victoria, British Columbia, included demonstrations of how to make a dry ice comet, lectures on supernova 1987A and Mars, and advice on buying binoculars.

"We encourage teachers to take the materials we give them and hold workshops in their own districts," said Fraknoi. "Since we started these workshops, there have been a hundred secondary workshops held across the country."

The workshops also spawned a newsletter, "The Universe in the Classroom," which the Astronomical Society of the Pacific sends out to 20,000 teachers. Each issue contains an article on a major science topic and a related classroom activity and bibliography. Pluto, Mars, and supernovae have been recent topics covered in the four-page quarterly newsletter.

Many science teachers lack adequate training in the basics of teaching astronomy.

The grassroots teacher training activities are not just coming from teachers and groups already committed to astronomy: corporations are also sponsoring workshops in the name of educating the next generation of scientists and technicians. Since 1982 Phillips Petroleum Company has sponsored an annual science teachers workshop in which Phillips scientists give talks on chemistry, geology, physics, and astronomy for three hundred teachers at its headquarters in Bartlesville, Oklahoma.

"The emphasis is hands-on science," said Phillips research chemist Ken Willcox, who gives the astronomy workshop. "We want to give teachers things they can do in the classroom to generate interest."

At this year's workshop, which focused on elementary school science, Willcox demonstrated how Styrofoam balls can be used to simulate lunar phases and eclipses and how relative solar system distances can be experienced by students using a Ping-Pong ball (for Earth) and a nice, straight local road ten miles long (the distance to Pluto).

Teachers, however, need more than creative classroom lessons to be effective: they also have to motivate students to learn. A unique pilot program developed by the Charleston County, South Carolina, school district and NASA emphasizes getting teachers excited about astronomy through direct involvement in scientific research. The goal is to instill in students the same enthusiasm the teacher experienced.

In August 1987 six teachers from Charleston County schools flew as guests aboard NASA's Kuiper Airborne Observatory (KAO) and photographed the Milky Way through a 36-inch telescope mounted in the jet. The photos have since been incorporated by the teachers into instructional slide programs that will be introduced districtwide in the 1988-89 school year. The enthusiasm the teachers brought back has already started to work.

"It's exciting for kids to see their teachers doing this kind of thing. They feel proud and really involved in what *their* teacher did," says Sharon Brower, science coordinator for the Charleston county schools.

"I was so enthusiastic when I got back," says eighth grade Earth science teacher Nancy Parsons, "that it had to stimulate the students more. They wanted to know all about what it was like up there."

The six teachers — none of whom had previous training in astronomy — underwent eight months of training in the basics of astronomy. Because the objective of the KAO flight was visual and infrared photography, the teachers received training in all aspects of astrophotography — use of filters, types of films, processing, and printing — and learned how to use a telescope and the celestial coordinate systems. The training was provided by a local planetarium and amateur astronomy groups and coordinated by James Nicholson of the Medical University of South Carolina.

The two KAO flights flew out of NASA Ames Research Center near San Francisco. The teachers piggybacked their cameras on the KAO telescope while astronomers observed the Milky Way. When the flights were over, the astronomers took away their computer data and the teachers took away their photos.

Although no second teacher training flight is currently planned, NASA is evaluating the project for possible use with other school districts.

The movement to improve astronomy education in the nation's elementary and secondary schools has grown beyond the grassroots efforts of teacher groups and individual school districts in recent years. Now significant contributions are being made by the professional astronomy community. The American Astronomical Society this year initiated workshops for local teachers at its two annual meetings. And, beginning this year, one of the country's newest astronomical institutions — the Space Telescope Science Institute in Baltimore, Maryland — joined the cause with a new educational affairs division and a week-long teacher workshop.

"We could become a major force in educational excellence in astronomy across the nation," says Eric Chaisson, head of the institute's educational and public affairs division. "Once the *Hubble Space Telescope* is in orbit, we'll be able to offer more workshops and open them up nationally."

At the inaugural workshop held in June, Chaisson gave twenty-five Maryland high school astronomy teachers an inside look at how science is done. Using hands-on laboratory activities in spectroscopy, optics, and lasers, Chaisson hopes to give teachers a solid background in both the fundamental concepts and the more advanced areas of astronomy.

"The teachers want substance, they want the science," Chaisson says. "They don't feel they're trained well enough in modern astronomy to satisfy their students. I'm just trying to give teachers what they want: an update on modern astronomy."

Chaisson is also planning to produce instructional materials using state-of-the-art computer graphics and video technology. Plans are under way to produce posters, hands-on activities, and slide presentations, based on the workshop held this summer.

Perhaps the most influential contribution astronomers are making to astronomy education is under way at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts. Supported by a grant from

GERARD P. KUIPER AIRBORNE OBSERVATORY
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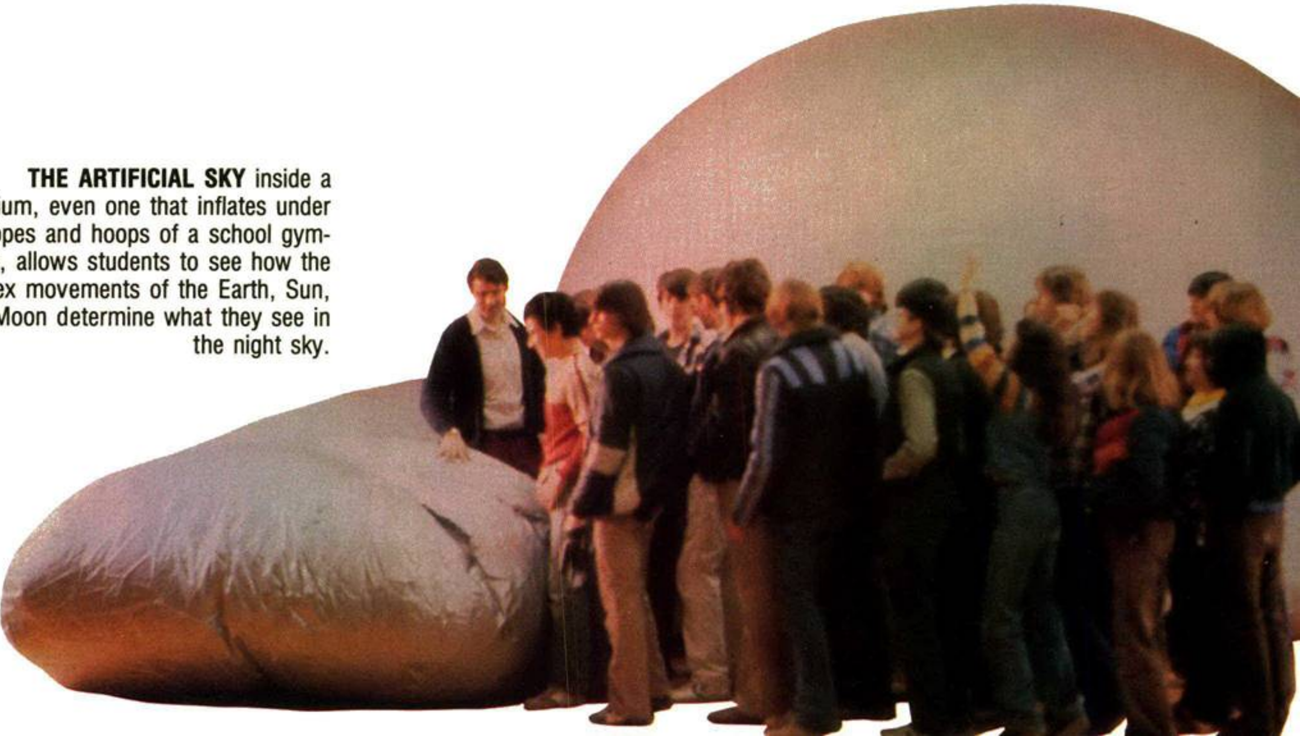
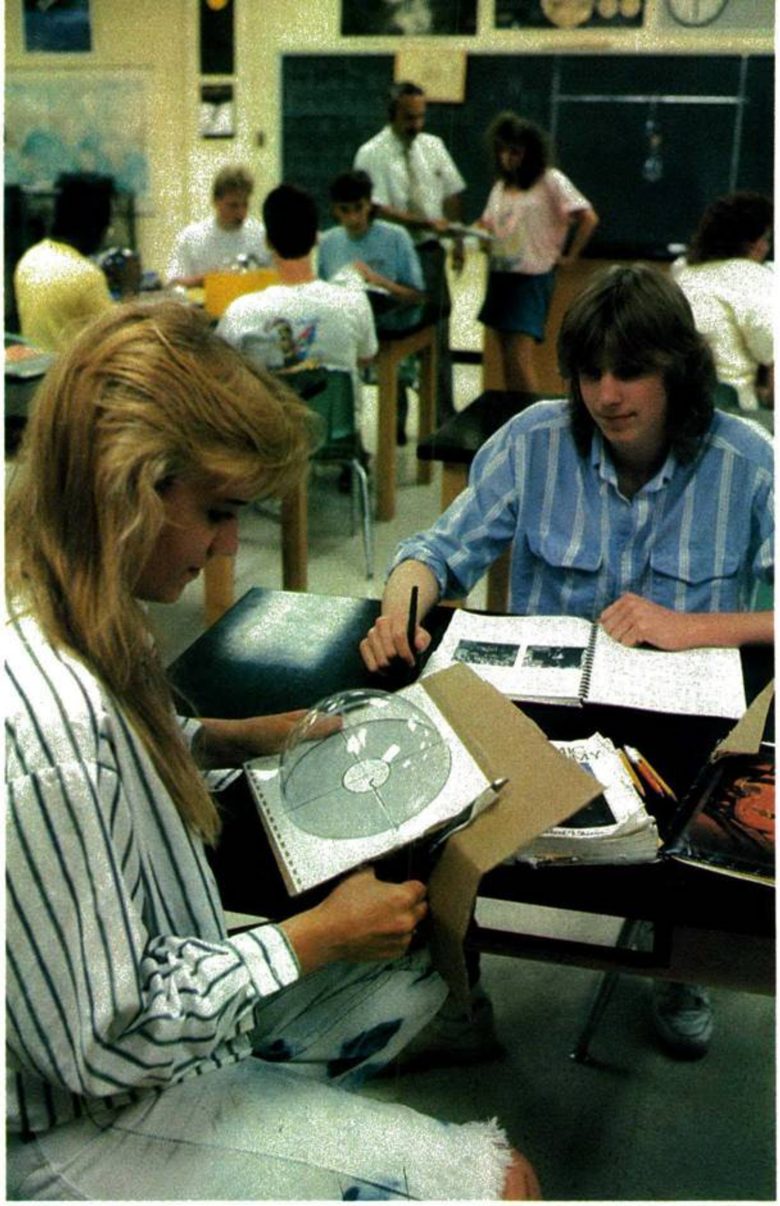
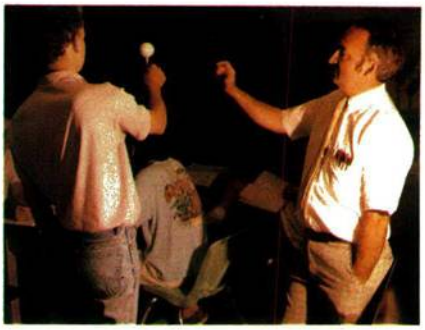
A FLYING CLASSROOM is where South Carolina teacher Nancy Parsons learned about the excitement of science. Parsons and five other teachers flew aboard NASA's Kuiper Airborne Observatory with astronomers as part of a teacher training program in astronomy.

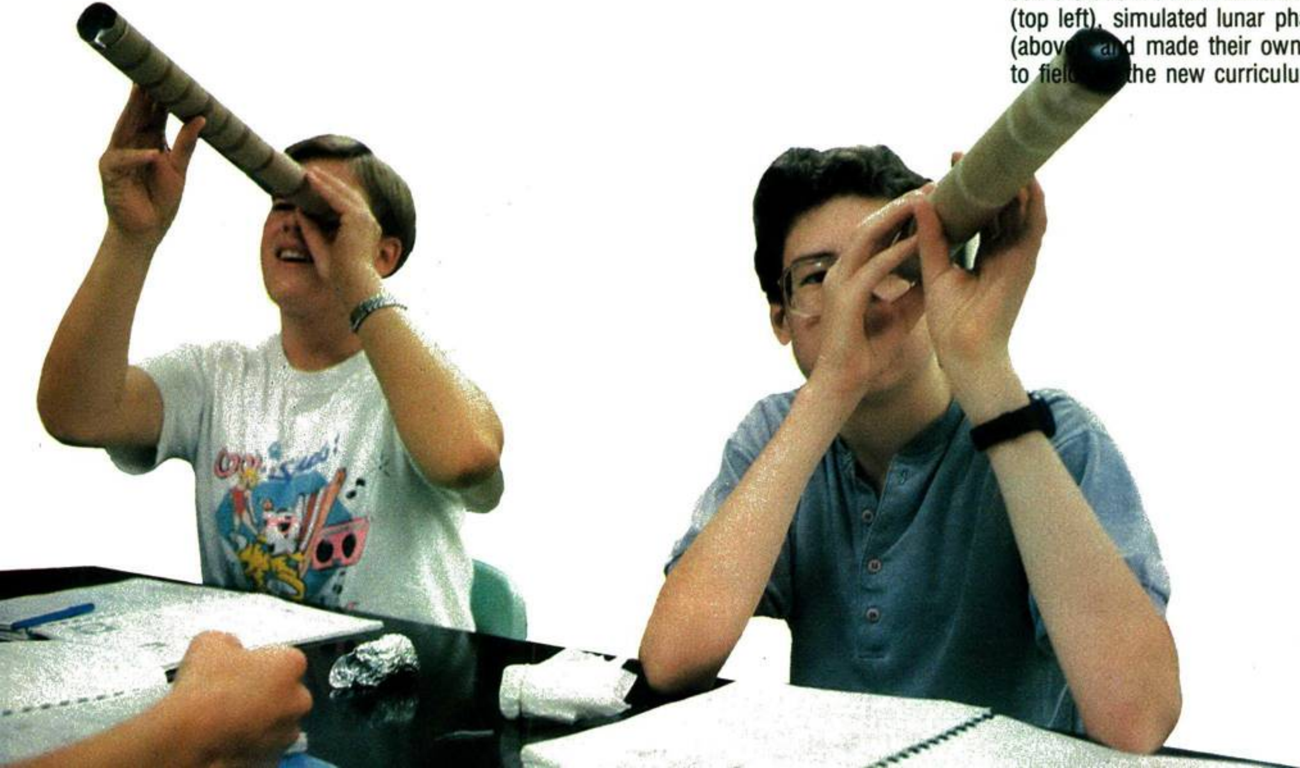
THE ARTIFICIAL SKY inside a planetarium, even one that inflates under the ropes and hoops of a school gymnasium, allows students to see how the complex movements of the Earth, Sun, and Moon determine what they see in the night sky.







A NEW ASTRONOMY COURSE for high schools, being developed at the Harvard-Smithsonian Center for Astrophysics, stresses hands-on activities. Wisconsin science teacher Gary Sampson's student's built celestial spheres (top left), simulated lunar phases (above) and made their own telescopes to field-test the new curriculum.



the National Science Foundation, astronomers at the center are working on Project STAR, a program to develop a year-long astronomy course for the nation's high schools.

With no high school-level astronomy textbook in print, teachers who offer astronomy courses have had to create their own curriculum from whatever resources they could find. Project STAR's goal is to develop an astronomy textbook and workbook, along with additional printed materials, videotapes, and software, and have those materials ready by the fall of 1991.

Curricula developed by university scientists are nothing new to American high schools: university-developed courses in biology and physics have been widely used for years. The Project STAR curriculum is being developed by a panel of scientists and a group of Boston-area high school teachers. Since the project began in 1986, Project STAR staff, scientists, and teachers have met each summer to test and revise the curriculum. The materials created to date were reworked this July after being tested nationwide in twenty-five schools during the 1987-88 school year; this fall the revised curriculum will be fieldtested again.

The Project STAR curriculum takes a nontraditional instructional approach. Instead of a textbook and lecture course that surveys many concepts, Project STAR focuses on the mastery of a few fundamental concepts through a series of hands-on activities. The goal is to give students a meaningful introduction to how science works — the STAR acronym stands for "science teaching through its astronomical roots" — instead of a cursory introduction to many astronomical facts.

The STAR curriculum will be made up of three units: the nature of light, which will focus on how light is used to reveal the temperature and size of celestial objects; the laws of nature, particularly the laws of motion observed in planets, stars, and galaxies; and orientation in space and time, in which students make the conceptual leap from an Earth-centered view of the universe. Only the space and time unit is completed so far.

The activities in this unit include making a telescope from paper-towel tubes and two plastic lenses (total cost: 50 cents) to observe lunar features and creating an artificial star from a flashlight and a piece of optic fiber to estimate stellar distances. The most popular project among students, according to project director Philip Sadler, was constructing a celestial sphere from two clear plastic hemispheres.

"It seemed odd to the astrophysicists working on this project that this two thousand-year-old concept was so popular," said Sadler. "But it's definitely the glue that holds together a lot of concepts about the sky."

Three years from now the Project STAR curriculum will be published and ready for use, but whether or not it ever finds its way into the hands of students is another question. In a democratic educational system where textbooks may be recommended to local school districts by state education departments but not required, the existence of good materials does not guarantee the widespread use of these materials. Will school districts across the country be interested in adding an astronomy course, given the shrinking pool of science teachers and the lack of training in astronomy?

Recognizing this problem, Irwin Shapiro, Project STAR principal investigator and director of the Harvard College Observatory, has proposed another project to the National Science Foundation that would give astronomy training to teachers at all grade levels.

The program, titled "Support Program for Instructional Competency in Astronomy," would use Project STAR staff to systematically train a national network of high school astronomy teachers who will in turn train teachers in their own communities. Pending approval by the NSF, the program will begin early next year.

Each summer for four years, thirty-two teachers will attend a four-week workshop at the Center for Astrophysics to learn about the latest science education theories and get hands-on experience with classroom materials. Over the duration of the program 128 teachers will be trained at these workshops. During the school year following the summer workshop each teacher will give two astronomy workshops, one within his or her own district and one outside of it, and reach an estimated forty-five additional teachers.

Enrollment in high school astronomy courses is predicted to increase tenfold in the 1990s.

Teachers will be trained to give a number of workshops on how to run a star party, use star maps and the celestial sphere, and effectively teach astronomy. Each teacher will also maintain a local "information office," either a post office box or a computer bulletin board, that workshop participants can write to for advice.

The program will also develop a network of amateur astronomers in cooperation with the Astronomical League that will "adopt an astronomy class" and offer evening observing sessions for the class. "Many teachers, especially new astronomy teachers, would like to have star parties," says Sadler, "but few have ever done that with groups of kids. Many amateur groups have."

Sadler is confident that the combined punch of a complete high school curriculum package and an ongoing teacher support program will dramatically increase the amount of astronomy taught in U.S. schools. "Right now only about 50,000 students take astronomy in high school each year, compared to the more than half a million who take physics. We can get that up to half a million in astronomy as well."

In the 1990s we may see the end of the cycle of astronomical ignorance that has been perpetuated in our school system for nearly a century. We will have to wait, however, to see whether that produces a more scientifically literate America.

But we can be certain that the students who do study astronomy will gain at least one benefit from their efforts, something that has little to do with careers and academic achievement. "If you can understand your place in the universe and appreciate the immense scale of that," says Jeanne Bishop, "you can begin to understand the unique kinds of abilities that humans really have compared to the mechanical universe. Without that perspective, I don't think that you can be a well-educated human being." ☐

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The perfect starter filter set, includes all the most important 1.25" filters. Basic set includes #80A Blue, #58 Green, #25 Red, #15 Yellow.
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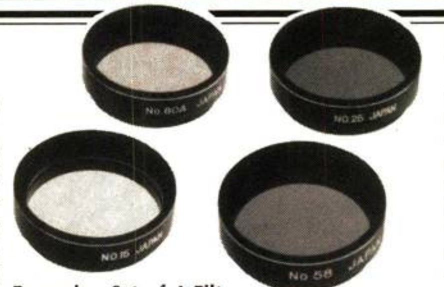

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- **#11 Light Yellow-Green** enhances detail while maintaining good detail on dark features. #5530
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- **#82A Very Pale Blue** sharpens atmospheric contrast without loosing brighter features. #5544
- **#80A Blue** enhances atmospheric visibility, maximizing surface contrast. #11040
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1.25" Eyepiece Ultra Block #5654 **$99** (1.68)

Rear Cell UltraBlock for Meade or Celestron 4", 8", 10" Schmidt-Cassegrains. #5656 **$139** (2.19)

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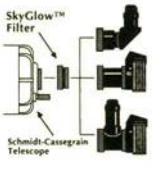

City bound astronomers, enhance your viewing of faint deep sky objects with the best broadband light pollution filter you can buy. Our SkyGlow filter absorbs the frequencies emitted by city lights, allowing transmission of the rest of the visible spectrum. You'll see dramatic results. Ideal for visual observation, and photography. Try one, you'll be amazed!

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for Meade & Celestron 8" SC's.
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High Power 1.25" Illuminated Reticle Eyepiece With Adjustable Reticle Positioning

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Bull's-eye 1.25" Illuminated Reticle Eyepiece With Adjustable Brightness

9mm Orthoscopic eyepiece with wireless adjustable brightness illuminator. Bull's-eye within three concentric circles helps measure limits of acceptable guiding error.
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1.25" Illuminated Reticle Eyepiece For Telescope Power Panels

12mm Kellner eyepiece with cable plugs into LX/3 and LX/5 drive bases, and most drive correctors with illuminated reticle output for polar alignment and guiding.
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Orion Universal Camera Adapter

Combination Eyepiece Projection Tube and Prime Focus Adapter for refractors and reflectors. Use with T-Ring to match your 35mm camera.

1.25" Model #5264 **$34.95** (1.68)
.965" Model #5268 **$34.95** (1.68)

Orion® T-Adapter

For prime focus photography. Use with T-ring to match your 35mm camera. For Meade, Celestron 8", 10" SC.
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For high powered photography with Meade, Celestron 8", 10" Schmidt-Cassegrain.
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Use with any 1.25" Illuminated reticle eyepiece. For Meade, Celestron 8",10" Schmidt-Cassegrain.
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Off-Axis Guiding System with 12mm Kellner eyepiece, #8482 (listed separately). #20272 **$129** (1.88)

Off-Axis Guiding System with 9mm Ortho eyepiece, #8488 (listed separately). #20274 **$169** (1.88)

Off-Axis Guiding System with 6mm Ortho eyepiece, #8487 (listed separately). #20276 **$189** (1.88)

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Tele Compressor Lens
***Fully* Multi-Coated**

Get four times the brightness and 1/2 the exposure time. Double your field of view for astrophotography. For Meade, Celestron 8", 10" SC.
#5141 **$34.95** (1.68)

Extension Tube
Needed when using Tele Compressor with Off-Axis Guider.
#5123 **$19.95** (1.68)

Orion® Rich Field Adapter
***Fully* Multi-Coated**

Adds 4x the image brightness and twice the field of view. For Meade, Celestron 8", 10" SC.
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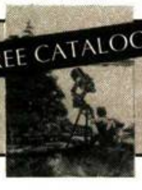

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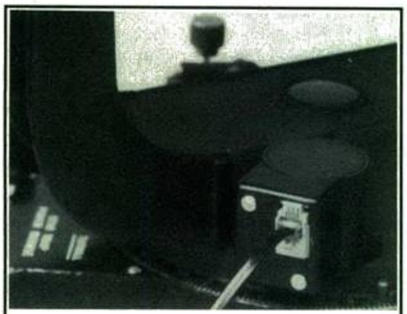

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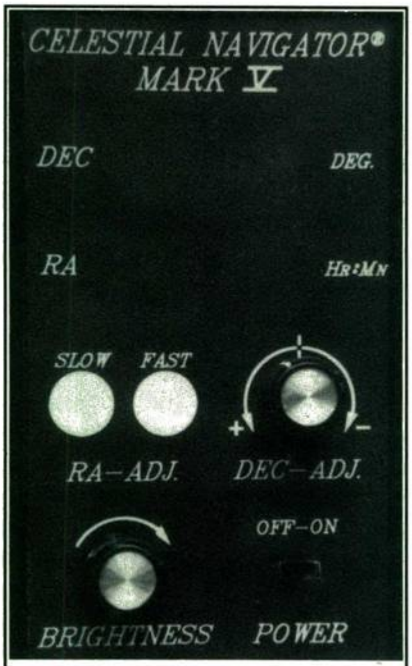

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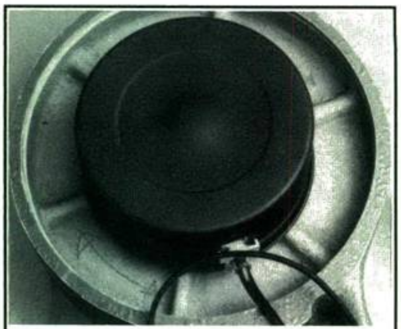

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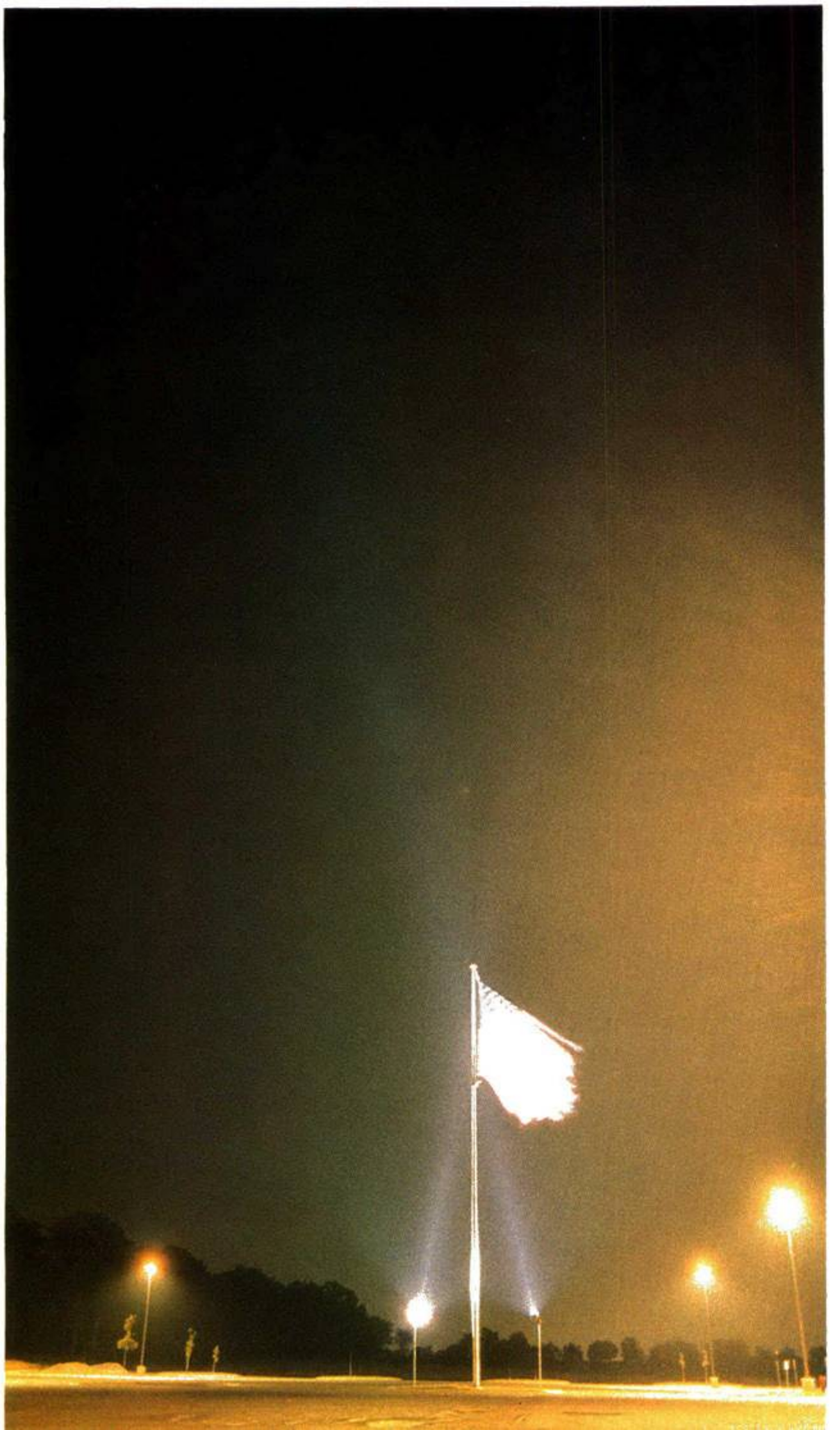
by Tim B. Hunter and Bob Goff



One of the most effective ways of reducing light pollution is to use light fixtures designed to light the ground, not the sky. It's easy, it's cheap, and it saves energy and money in the long run. Best of all, installing these fixtures is something that can be done now.

For most suburban amateur astronomers, backyard observing means looking at a handful of stars shining feebly through a sky brightened by the cast-off glow of streetlights, buildings, parking lots, and outdoor advertisements. Finding a dark, light-free sky where the Milky Way can be seen in all its glory requires driving fifty to a hundred miles out of town.

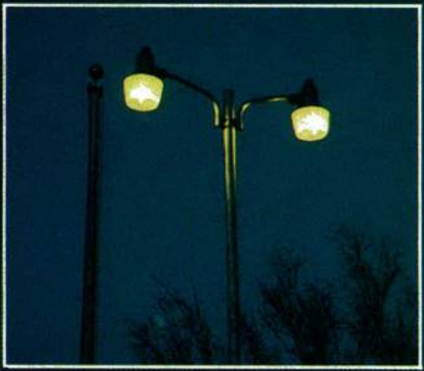
For professional astronomers the situation is even more serious: urban sky glow threatens — and in some regions of the country has already doomed — many professional observatories. Advances in our understanding of the universe depend on the ongoing research at these observatories.

But light pollution does more than endanger astronomical research and deny us views of a dark, natural night sky. It is a daily annoyance, intruding where it is not wanted or needed: in our windows, yards, and eyes. Ineffective light use also wastes both energy and taxpayers' money. In some cases poorly directed lighting can actually be a hazard because it shines more into your eyes than on the subject, which might be a busy highway intersection or a sharp curve in the road.

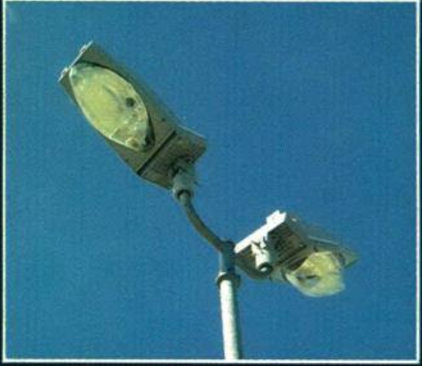
The worst offenders are poorly designed light fixtures, unshielded lights, and misapplied light sources. For example, streetlights without shields or with partial shields allow light to scatter out the sides of the fixture and into the sky. Globe fixtures have no shielding, so as much light goes up into the sky as on the ground. In the suburbs unshielded lights not only light up the yard, they light up the neighbors' yards too.

A Field Guide to Light Fixtures

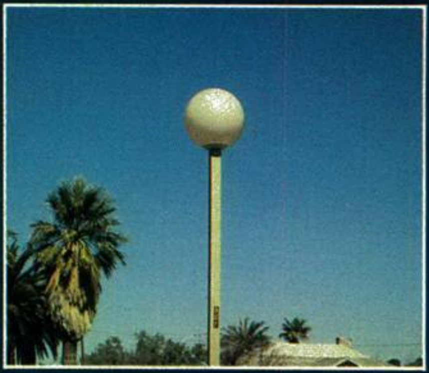
Very Bad



DOUBLE-BARRELED LIGHTS have no shielding. Though they typically contain mercury vapor bulbs, they can be designed to hold any bulb type.

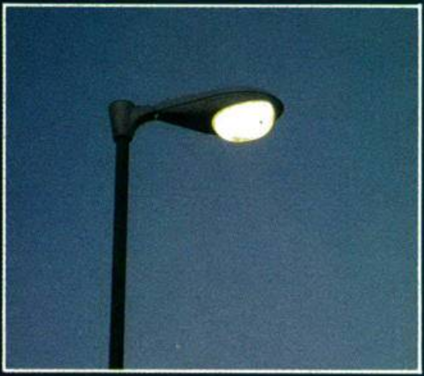


TOTALLY UNSHIELDED bulbs allow light to scatter out the sides of the fixture.

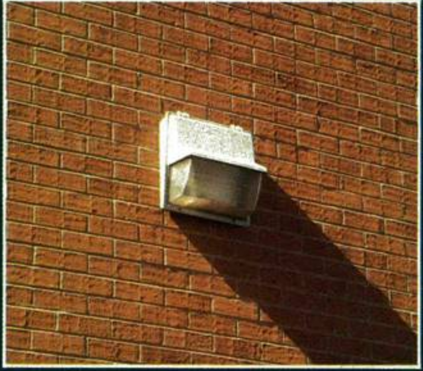


GLOBE-DESIGN FIXTURES are one of the worst light polluters because they send light upward and sideways.

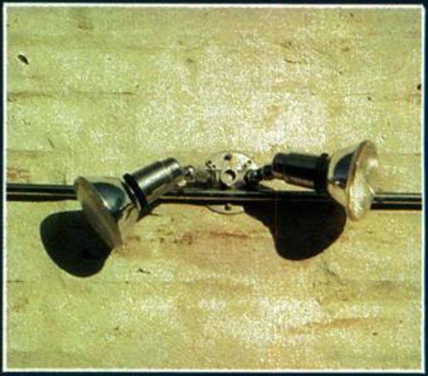
Bad



COBRA HEAD FIXTURES have minimal shielding but direct the light downward somewhat.

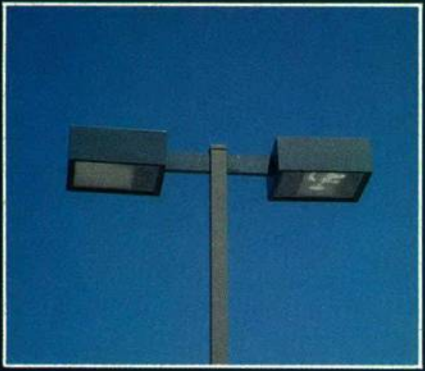


WALL PACK FIXTURES are unshielded and direct intense light sideways.

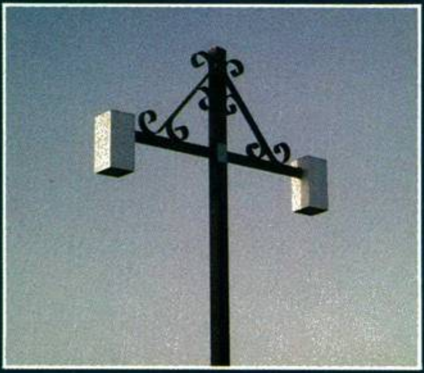


BACKYARD FLOODLIGHTS are often aimed upwards or sideways. They are more effective if they are shielded and aimed downward.

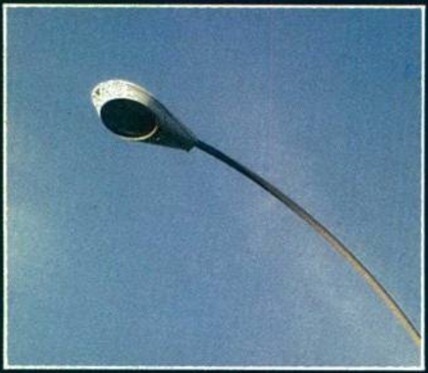
Good



SHIELDED FULL CUTOFF fixtures are common in the Tucson area. They provide excellent ground lighting with little or no light waste.



SHIELDED WALK LIGHTS prevent light waste by illuminating the path, not the sky.

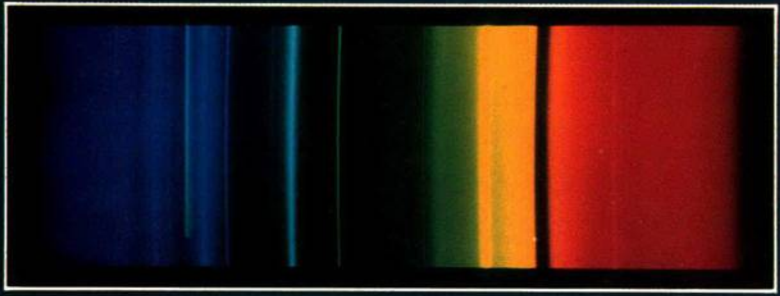


SHIELDED STREETLIGHTS produce excellent ground lighting but little sky glow.

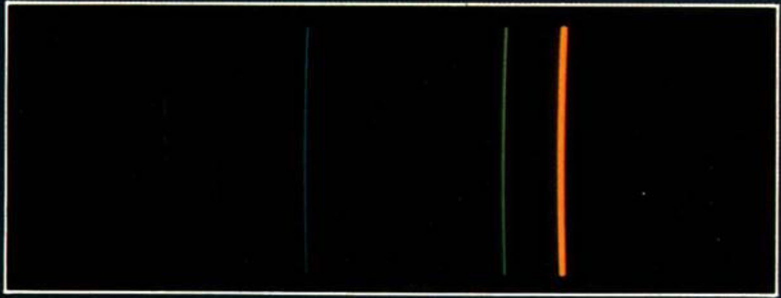
A DOWNWARD CONE OF LIGHT is the sign of a well-designed shielded fixture that produces little sky glow.

CYLINDRICAL SHIELDS on building lights prevent light leakage. Similar designs could be used effectively for outdoor house lighting.

A Curtain of Light

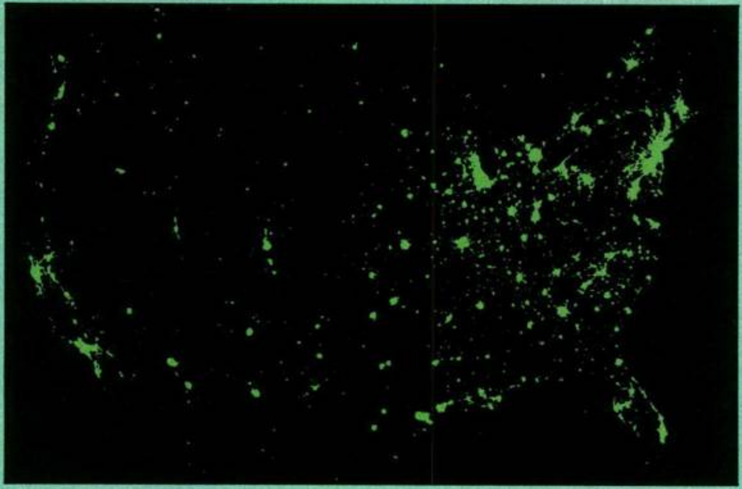


HIGH-PRESSURE SODIUM lights emit a continuous spectrum that blocks our view of the night sky.



LOW-PRESSURE SODIUM lights emit two closely adjoined yellow emission lines that can be filtered out by astronomers.

Working with Local Governments to Fight Light Pollution



The following guidelines are excerpts from *Light Pollution: The Adverse Impact of Urban Sky Glow on Astronomy and on the Environment* by David L. Crawford, an astronomer at the National Optical Astronomy Observatories and chairman of the American Astronomical Society's committee on light pollution and radio interference. Crawford offers some ground rules for working with community leaders, officials, and the general public on the light-pollution issue.

1. Go to the city or county staff for information [usually the planning and zoning commission] to work out problems at that level. Establish and maintain one-to-one relationships.
2. Do your homework. You must be well prepared. Don't waste people's time if you are not. You will lose their confidence, if you had any. Don't be repetitive. Do give short and clear presentations. Show both sides of the issue. Emotional appeals carry little weight, especially when not backed by good facts or when only backed by inaccurate or biased facts. Know more about the issue than they do.
3. Facts are not enough, however. Personal relations are very important and are in play all the time.
4. Make positive approaches, not negative or combative ones. Offer alternatives. Be flexible to local needs. Show how others will benefit too, including the officials and the public.
5. Assess the opposition. Resolve known conflicts or misunderstandings, if any, before any hearing.
6. Be prepared to compromise, but always keep the overall goal in sight. *Do not compromise that.* Know what the opposition's strong points are so you can develop counter arguments and facts and allies.
7. Participate in local hearings, study groups, and advisory committees. Recognize that you must make a major commitment of your time.
8. Be tactful. Don't argue. Government workers get hassled all the time. Don't make personal attacks. Be professional, polite, helpful. Always be completely ethical, open, and honest to everyone.
9. Ask for advice; let individuals tell you how to change their point of view. Most people really like to be helpful when they can. Ask them how they can help. Informal communication is very effective. Don't just communicate when crises exist; be in touch regularly.
10. Show appreciation for anything you gain, for successes, and for help.

A copy of the light-pollution booklet can be obtained from David Crawford at the National Optical Astronomy Observatories, Kitt Peak National Observatory, Box 26732, Tucson, AZ 85726. A $5 donation is requested.

The aim of light-pollution control is not to abolish lights but to seek nighttime lighting that directs light on the ground where it is needed. Astronomers, too, have the same lighting needs as the general public; they appreciate lighted streets and parking lots. But common sense says there is no use lighting up the sky if the purpose is to illuminate a billboard or a parking lot.

One solution is *shielded* fixtures that enclose the light source so all of the light is directed downward. With such a shield, called a full cutoff shield, the bulb is only visible from directly under the lamp, and a well-demarcated cone of light shines downward. Partially shielded and unshielded fixtures, such as globes, "cobra head" streetlights, and wall fixtures, throw a great deal of light sideways and into the sky.

Astronomers also encourage the use of low-pressure sodium (LPS) light wherever possible because this type of lighting produces an essentially monochromatic yellow color that can easily be filtered out, unlike high-pressure sodium, mercury vapor, and incandescent lighting.

Where color rendition is not important, such as in residential areas and parking lots, fully shielded LPS lights are appropriate. Moreover, LPS lighting is less costly to operate and saves energy. Shielded LPS lighting is clearly the best choice for providing adequate illumination while minimizing sky glow.

The first step toward solving the light-pollution problem is learning what distinguishes good lighting from bad. The next step is encouraging city and county governments to use good fixtures, to replace the bad ones, and to apply LPS lighting wherever possible. If such measures can be backed up with light-control ordinances, much of the light-pollution problem would be solved within a few decades.

It is unfortunate that we're the first generation that has been denied convenient access to a dark, natural sky. Other than what they have seen on the domes of planetariums, many people don't know how truly beautiful and awe-inspiring the night sky is. Why should we deny ourselves and our descendants the splendor of the heavens? □

Tim B. Hunter is president of the International Dark-Sky Association, a clearinghouse on light pollution and related topics. Bob Goff, also involved in IDA, is a master optician.

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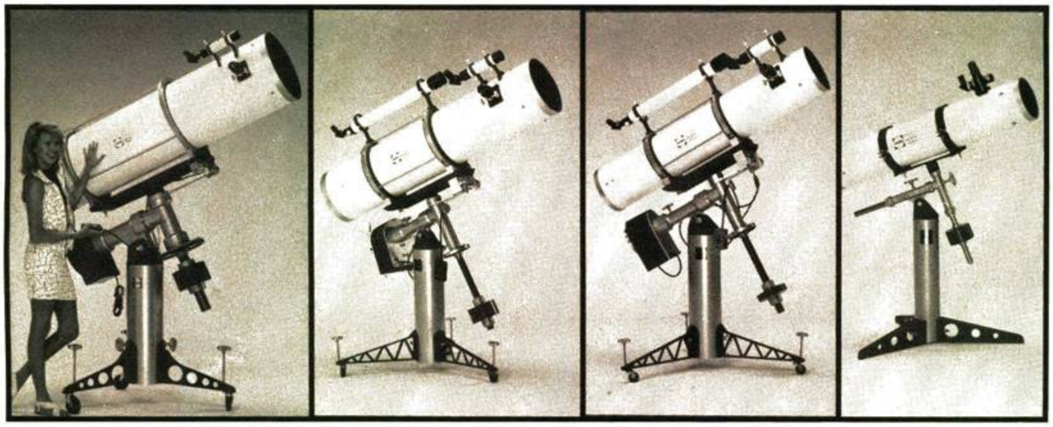
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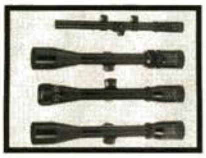
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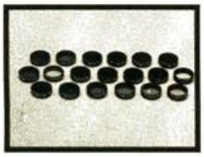
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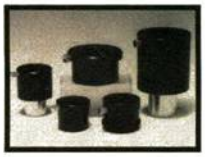
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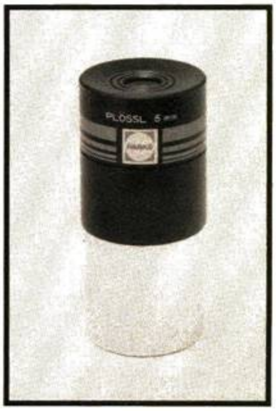

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Pluto Emerges from the Shadows

By analyzing Pluto's light curve during a rare series of eclipses, astronomers are beginning to "see" the surface of Pluto.

by David J. Eicher

"This is the most wonderful time in the history of Pluto science." Richard P. Binzel, a Pluto researcher at the Massachusetts Institute of Technology, has good reason to be excited. Over the past three years Pluto and its moon Charon have undergone a series of eclipses. By measuring the eclipses with a wide array of instruments and techniques, astronomers have learned more about Pluto — Pluto's size, density, composition, and surface characteristics — in the past three years than they had learned since the planet's discovery in 1930. The most exciting possibility is that astronomers may be able to map the surfaces of Pluto and Charon.

The chief problem with investigating Pluto has been the planet's small size and great distance from Earth. (The average distance to Pluto is 2.7 billion miles.) The only previous breakthrough came in 1978, when James W. Christy of the U.S. Naval Observatory discovered a moon orbiting Pluto and named it Charon.

Shortly after the discovery of Charon, astronomers realized that in about ten years Pluto and Charon would undergo an eclipse cycle. "This is one case where nature was kind to us," says Binzel. "We didn't have to wait for more than a century until the eclipses began." Our line of sight would change, so Charon's 6.4-day orbit would carry the moon directly in front of and behind Pluto. This cycle is rare: it occurs once every 124 years.

Because of uncertainties about Charon's orbit around Pluto, astronomers didn't know exactly when the eclipses would start. From Earth the Pluto-Charon system appears as a single faint dot of light — the images of Pluto and Charon merge together — so using a photometer is the only way to detect the eclipses.

A photometer precisely measures the brightness of a star. Coupled to a large telescope, a photometer can detect a dip in the amount of light from the Pluto-Charon system. A dip occurs when part of the surface of Pluto or Charon is temporarily blocked or shadowed, which reduces the total amount of sunlight reflected by the two bodies.

In February 1985 Binzel observed the first eclipse while monitoring Pluto at McDonald Observatory in Texas. This event altered the scope of Pluto research. The odds of gaining important information about Pluto and Charon were high, so many scientists began studying Pluto. What was once a small group of specialists became a highly competitive crowd. Pluto research became big business.

Photometry remains the fundamental way of gathering data on the Pluto-Charon system. By measuring the depths and durations of dips in the light intensity of Pluto-Charon, astronomers obtained precise measurements of size for the two bodies — quantities they had previously known only to an accuracy of 50 percent. From a sequence of eclipse data gathered over three years, University of Hawaii astronomers David Tholin and Marc Buie calculated the diameters of Pluto and Charon as 1,400 miles and 745 miles, respectively.

Because the astronomers knew the distance of the Pluto system from Earth and the orbital distance of Charon, they arrived at accurate diameters by studying the durations of eclipses. These sizes are much smaller than astronomers previously suspected. However, the relative size of Charon is large compared to the size of Pluto. Because of this, Binzel and other Pluto scientists think of Pluto and Charon as a "double planet."

Apart from assembling fundamental data, astronomers are anxious to map the surface of Pluto. "During the eclipse cycle," Binzel explained, "Charon began transiting across the northern hemisphere of Pluto. During the last two years it has transited across Pluto's equatorial region. During the next year it will transit across the southern hemisphere of Pluto. By comparing the light curves, we hope to model the surface of Pluto." If Pluto's surface is uniform, the light curves will show no bumps or wiggles. If there are bumps and wiggles, Binzel and his colleagues can produce a crude surface map of light and dark patches on Pluto. From photometric data Binzel already knows that Pluto is a much darker object than Charon.

The limitation on Pluto surface mapping, however, is imposed by the system's orbit. Pluto are Charon are in a synchronous orbit, which means that Charon always transits the same side of Pluto. At best, astronomers can produce a map that shows one hemisphere of Pluto's surface. In the same manner, however, Binzel hopes to discover something about the nature of Charon's surface. "If there are variations in albedo on Charon," he said, "we should be able to map the surface of Charon in a crude way."

Spectroscopy also plays a major role in the current Pluto research. "Another exciting thing about this year's eclipses is that we're getting total occultations of Charon behind Pluto's disk," Binzel said, "so we can get individual spectra of Pluto and Charon. We do this by making a spectrum before the occultation, which gives us the combined spectra of Pluto and Charon. We then make a spectrum of Pluto alone during an occultation, and subtract the second spectrum to get Charon alone."

After studying the two individual spectra, Binzel was surprised to find that Pluto shows a distinctly reddish spectrum, while Charon's spectrum indicates the moon is neutral in color. This may mean that Pluto has a coating of methane ice on its surface, while Charon's lower gravity hasn't

WORKHORSE FOR SCIENTISTS, the Cray X-MP/48 supercomputer models Pluto-Charon eclipses and surface features.

retained any methane ice the moon may have once had. Binzel believes a layer of water ice may cover the surface of Charon.

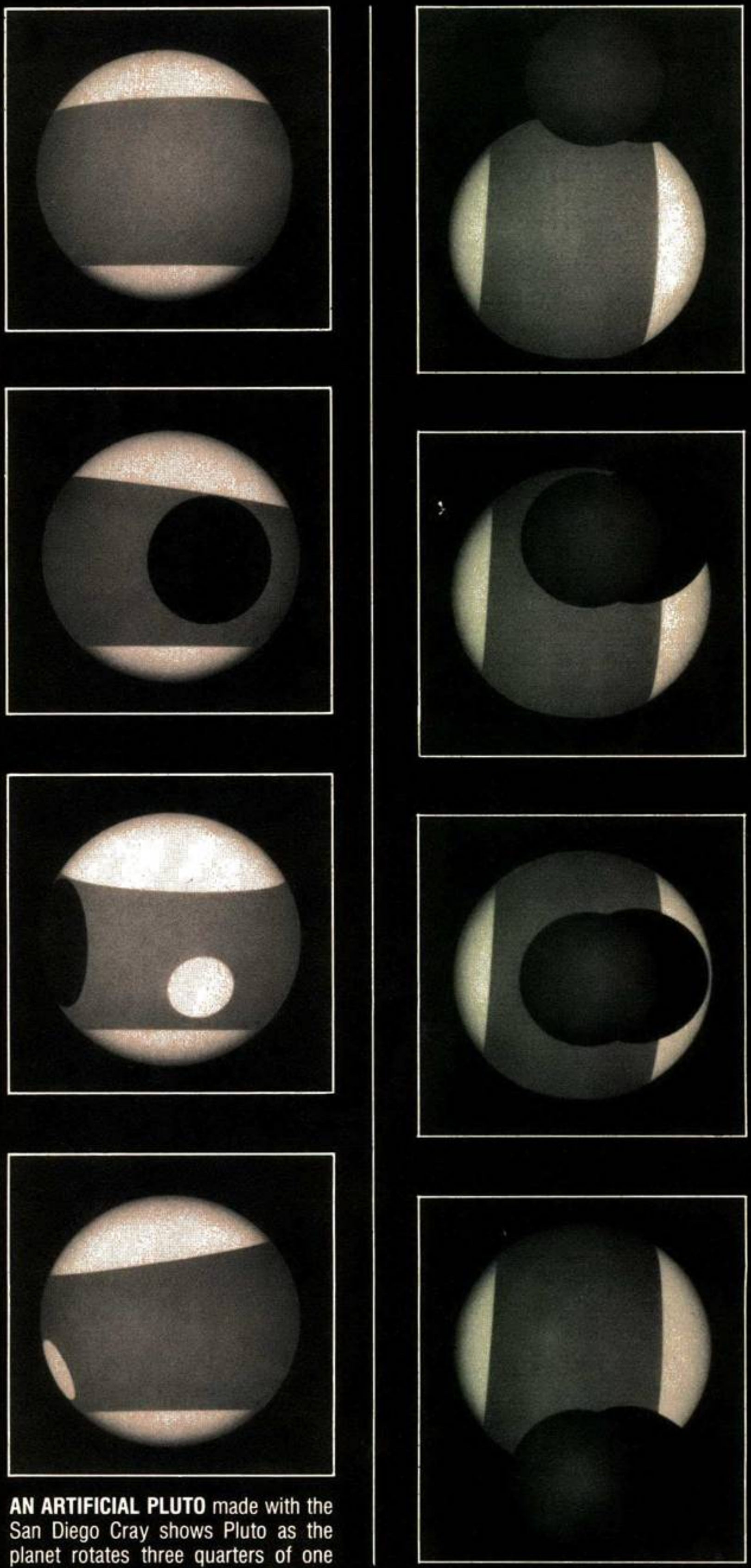
Another group of astronomers is investigating Pluto with high-tech supercomputers and sophisticated computer models. Both Marc Buie at the University of Hawaii and Robert Marcialis of Vanderbilt University have devoted much of their research to computer modeling.

Their approach is to match computer models of Pluto's surface that, when rotated to match Pluto's rotation, produce the actual dimming and brightening observed by astronomers at the telescope.

Buie used a Cray X-MP/48 supercomputer at the San Diego Supercomputer Center to make a film of Pluto based on his research. The movie shows two facets of Buie's Pluto modeling: a rotating Pluto with one bright spot and one dark spot, and a transit of Charon.

"We can say from my model," Buie said, "that the polar regions on Pluto are very bright and would be consistent with a pure frost of some kind. We have spectroscopic evidence that this material is most likely methane ice. Methane is an important material because its vapor pressure is such that it can actually migrate around. It can evaporate and resublimate over a time scale of years, so it probably explains the observed albedos on the planet, which may be slowly changing."

Three years of observing Pluto eclipses have so far provided astronomers with a spectacular opportunity to study the most distant planet. "Our goal," Binzel said, "is to take full advantage of this rare opportunity to learn as much about Pluto as we can. Any significant improvements over the results we hope to obtain will probably have to wait until we can send a space probe to Pluto. And no one knows when that might be." ☐



AN ARTIFICIAL PLUTO made with the San Diego Cray shows Pluto as the planet rotates three quarters of one revolution (left column). Pluto's north pole is at top. The sequence at right simulates a four-hour transit of Charon across Pluto. North pole at right.

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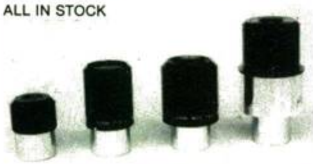

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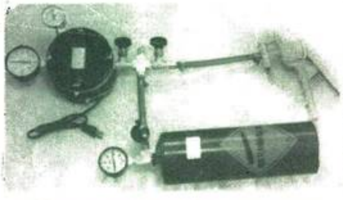

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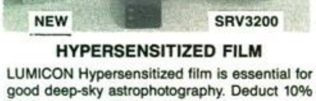

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Konica SR3200, unhypered	24	$8.50
Konica SR400, fine grain color neg	12	$10.95
3M 1000, fastest slide film	12	$12.95
Fujichrome RD100, fine grain slide	24	$12.95
D-19 B&W Developer	1 gal.	$6.95

LUMICON means INNOVATION

LUMICON, 2111 Research Dr., #5
Livermore, CA 94550 (415) 447-9570

LUMICON® SKY VECTOR™- *NEW!*

Computer-Controlled Digital Setting Circles, from $498

Sky Vector ™
ON OFF
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DIM
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MODE
STAR
LUMICON

LUMICON SKY VECTOR™ computer, showing digital readout of coordinates, and easy-to-use controls. Shaft encoders are included (not shown). $10 Gift Certificate if you identify the object at the coordinates given.

The LUMICON SKY VECTOR™ is a computer-controlled digital setting circle system. It represents a break-through in both computer performance and low price. The SKY VECTOR™ uses state-of-the-art components and is smarter and faster than other systems using 5 year old technology offered for up to $1000 higher price. The difference is memory. Instead of storing 8000 objects in memory, and charging $1000 more, we recommend purchase of a *Sky Catalogue 2000.0* for $30. To find an object just move the telescope until the coordinates of the SKY VECTOR™ match those of the object desired.

Incredibly Smart!
thus
Incredibly Easy!

- Digital right ascension readout to 1 minute of R.A.
- Digital decl. readout to 10 arc-min
- Digital altitude readout to 1°
- Polar alignment **not required!**
- Just sight two stars!

The computer's sophisticated program (over 3000 lines of code) determines **everything** from an initial sighting of just two stars!

- **No need** to enter latitude, longitude, siderial time, local time, date, etc., etc.
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080. The computer automatically knows the difference.
- Uses Epoch 2000.0, 1975.0 or 1950.0 coordinates.

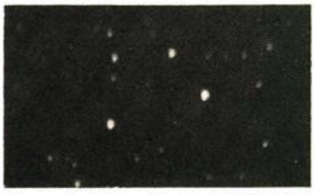
Light weight, only 2 oz. permits mounting near the eyepiece, if desired. Only 2.6"x2.6"x1" in size.

9V Battery lasts many nights.

Each LUMICON SKY VECTOR™ includes one computer with digital readout, two precision digital shaft encoders, connecting cables, and mounting hardware (for the most popular telescopes). **Please specify telescope type.**

LUMICON SKY VECTOR™ FOR C-11, C-14 *(Specify telescope)*	**$525**
for Coulter Odyssey 8", 10", 13", 17½" *(Specify telescope)*	**$498**
for Meade 2080,2120, Celestron C-8 *(Specify telescope)*	**$498**
SKY VECTOR KIT You must supply adapting hardware. Skilled ATM's only	**$469**
Pair, digital shaft encoders (for 2nd telescope), per pair	**$135**

LUMICON® COMA CORRECTOR LENS



Coma 1 inch off-axis 17½" f/4.5 Newtonian (2" Easy-Guider for Mamiya 645)

Same Field with LUMICON coma corrector lens, note smaller stars, and more numerous faint stars.

This computer-designed LUMICON 2" lens reduces coma and flattens the field for both viewing and photography. It threads into LUMICON 2" EASY-GUIDERS for effortless installation. This lens is optimized for f/4.5 and reduces aberrations for f/3.5 to f/5 Newtonians. Off-axis images are much smaller, making off-axis guiding far easier and yielding round pinpoint star images in photos. Since star images are sharp over a full 2¼" circle, you can use medium format cameras in addition to 35mm cameras. This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Although designed for photography you may also use this lens to improve image quality in wide-field viewing with low power eyepieces.

LUMICON Coma Corrector/Field Flattener	**$285.00**
LUMICON 2" EASY-GUIDER (state camera type)	**$169.50**
2" EASY-GUIDER for Mamiya 645	**$199.50**
Adapter for Hasselblad	**$185.00**
Adapter for Bronica SQ-A	**$175.00**
2" Extension tube (for viewing)	**$26.00**

Coma Corrector/Field Flattener lens

ADD "MEMORY" to the LUMICON SKY VECTOR™

Burnham's *Celestial Handbook*, Vol. I, II, III (Epoch 1950.0)	**$36.85**
The *Revised New General Catalogue* (all NGC and IC, Epoch 1975.0) .	**$35.00**
Sky Catalogue 2000.0, Vol II, doubles, variables, deep-sky objects	**$29.95**

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NEW! LOW PROFILE HELICAL FOCUSERS

FROM $49.50

LUMICON® DELUXE NON-ROTATING HELICAL FOCUSER on a 6" telescope.

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½" above the telescope tube. Use the 1¼" or 2" versions for viewing. Use the 2" non-rotating focuser for convenient photography with the LUMICON 2" EASY-GUIDER™.

Select your desired base-plate shape! Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 21" OD, SUPER-FINDER base plate.

LUMICON 1¼" Helical Focuser	**$49.50**
LUMICON 2" Helical Focuser	**$59.50**
LUMICON Non-rotating Helical Focuser	**$79.50**
3 handles (see photo) for non-rotat. focuser	**$12.95**
2"/1¼" **adapter** w/48mm filter threads	**$20.00**
2" **LUMICON EASY-GUIDER**	**$169.50**

EYEPIECE PROJECTION

These adapters allow high magnification photography of the Moon and Planets using eyepiece projection. They may be used without any eyepiece for prime-focus photography. All adapters use standard camera T-rings.

Tele-Extender for Meade or Celestron SCT.	**$32**
1¼" Basic Camera adapter, 2 part system	**$32**
0.96" Basic Camera adapter, 2 part system	**$32**
1¼" prime Focus adapter, fits 1¼" focuser	**$22**
0.96" prime Focus adapter, fits 0.96" focuser	**$22**
Camera T-ring, specify 35mm camera type	**$12**

LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat. The deluxe SUPER-FINDER uses an 80mm, F=500mm air spaced achromat.

1¼" 50mm Finderscope **$59.50**, right-angle	**$89.50**
1¼" straight-thru 80mm SUPER-FINDER ...	**$169**
1¼" right-angle version, w/star diagonal	**$195**
2" right-angle version, non-rotating focuser ..	**$199**
1¼" Deluxe right-angle Super-Finder*	**$279**
2" Deluxe right-angle Super-Finder*	**$309**
25mm Cross-hair 1¼" eyepiece (12X)	**$29**
*1¼" Star Diag. **$32**, 2" Star Diag., silver,	**$145**
1¼" Amici Prism diag. for correct left-right views	**$59.50**

2" ADAPTERS MEADE, CELESTRON TELESCOPES

These adapters convert refractors and Schmidt-Cassegrain telescopes for 2" operation. They allow use of 2" accessories, such as the LUMICON 2" EASY-GUIDER for photography. They also allow use of 2" eyepieces and/or 2" star diagonal for viewing.

2" adapter for C-8, Meade 2080, etc....	**$26.00**
2" adapter for Criterion 4000, 8000 ...	**$26.00**
2" adapter for C-80, C-90, C-100	**$39.50**
2" adapter for C-70, C-80F, C-90F, C-100F	**$39.50**
2" Accessory adapter for Comet Catcher*, C-6*, Meade 310, 320 refractor	**$30.00**
2" adapter for Takahashi E-130, 160 ..	**$59.50**

1.5x, 1.8x MULTIPLIER LENS

1.8x Multiplier Lens

The computer-designed LUMICON 2" Multiplier/Field Flattener multiplies the image scale in photography by 1.8x (f/4.5 becomes f/8). Use it with any LUMICON 2" EASY-GUIDER. It multiplies by 1.5x without the included extension tube. This lens is optimized for f/4.5, but will work well with any optical system. It may also be used visually as a highly corrected 2" Barlow lens.

LUMICON 1.8X Multiplier/Field Flattener	**$195**
LUMICON 2" EASY-GUIDER (state camera)	**$169**

VIEWING ADAPTERS

2"/1¼" Adapter, threaded 48mm filters ..	**$20**
2"/T - Thread adapter, threaded 48mm ..	**$25**
T - Thread/1¼" adapter. Converts telephoto lenses for viewing as finderscopes	**$25**

EXTENSION TUBES

1.0" long Thread-in extension tube	**$12.00**
1-2½" long, threaded for 1¼" filters	**$16.00**
4½" long extension tube, 1¼" i.d.	**$25.00**
2" i.d. Extension tube, 3" long, threaded for 48mm filters, adds 1.6-3.0"	**$26.00**

48mm COLORED GLASS FILTERS

These 48mm Filters thread into LUMICON EASY-GUIDERS and most 2" eyepieces. Use adapter for 1¼" eyepieces. AR Coated.

Filter:	**Bandpass**	**Trans**	**Price**
Ultraviolet	320-420nm	85%	**$35**
Minus Violet	420nm-IR	96%	**$29**
Blue Tricolor	340-470nm	80%	**$35**
Hi Perf. Blue	300-540nm	95%	**$35**
Yellow	480nm-IR	98%	**$18**
Green	490-590nm	60%	**$18**
Orange	560nm-IR	98%	**$18**
Red	600nm-IR	98%	**$18**
H-Alpha Pass	640nm-IR	95%	**$35**
Cyan	340-580nm	95%	**$59**

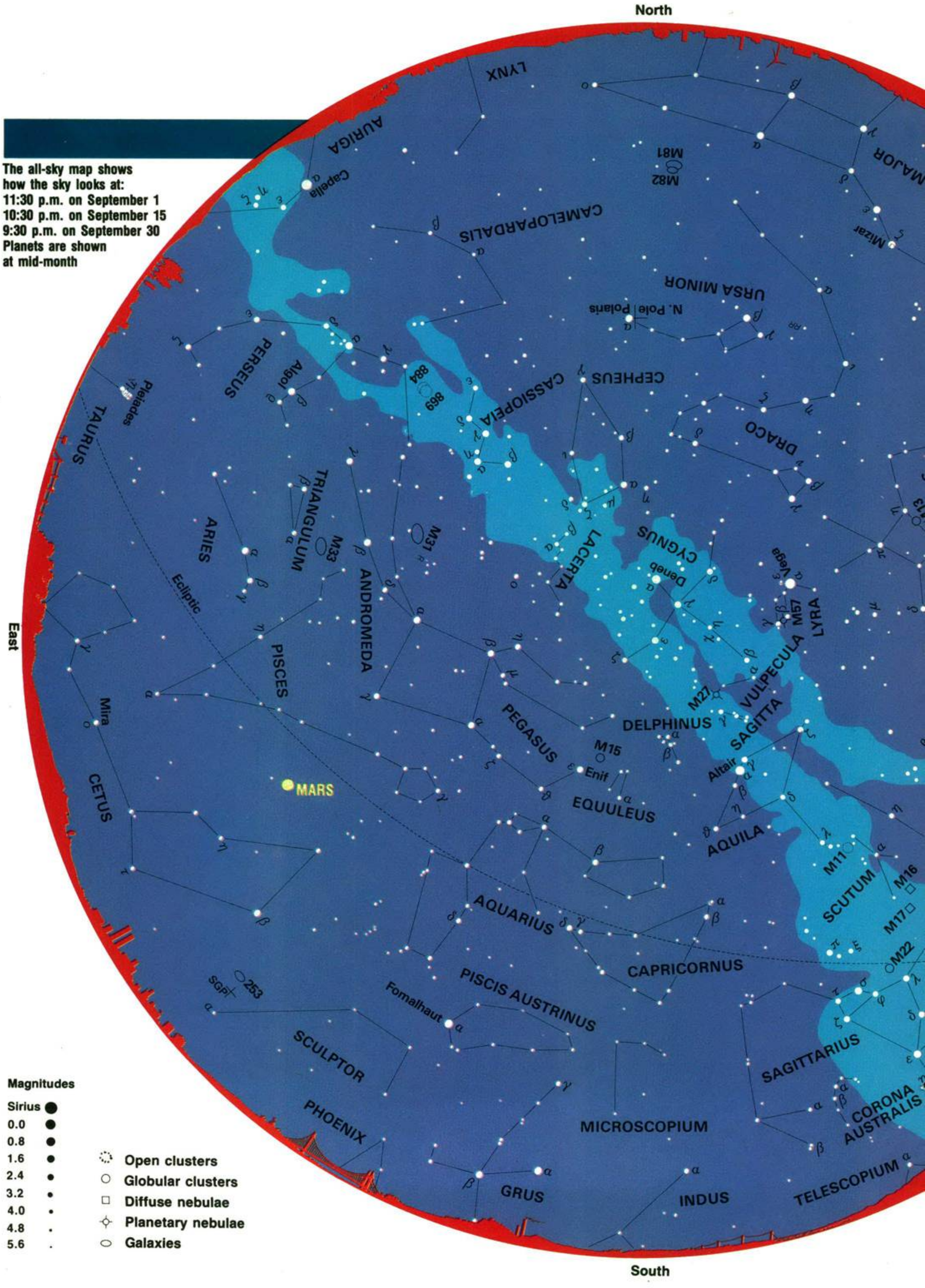
LUMICON NGC NOTES
OBJECT DESCRIPTION
VIEWING CONDITIONS
EYEPIECE DRAWING

NGC NOTES

These handy **NGC NOTES** are stiff 4"X5½" cards. the **NGC NOTES** fit in your hand and are ideal for making notes and sketches while observing at the eyepiece. Making sketches **greatly improves** your observing skills and also gives you a permanent record. Get 200 **NGC NOTES** for Messier objects; NGC object observers should get 400-800 **NGC NOTES.**

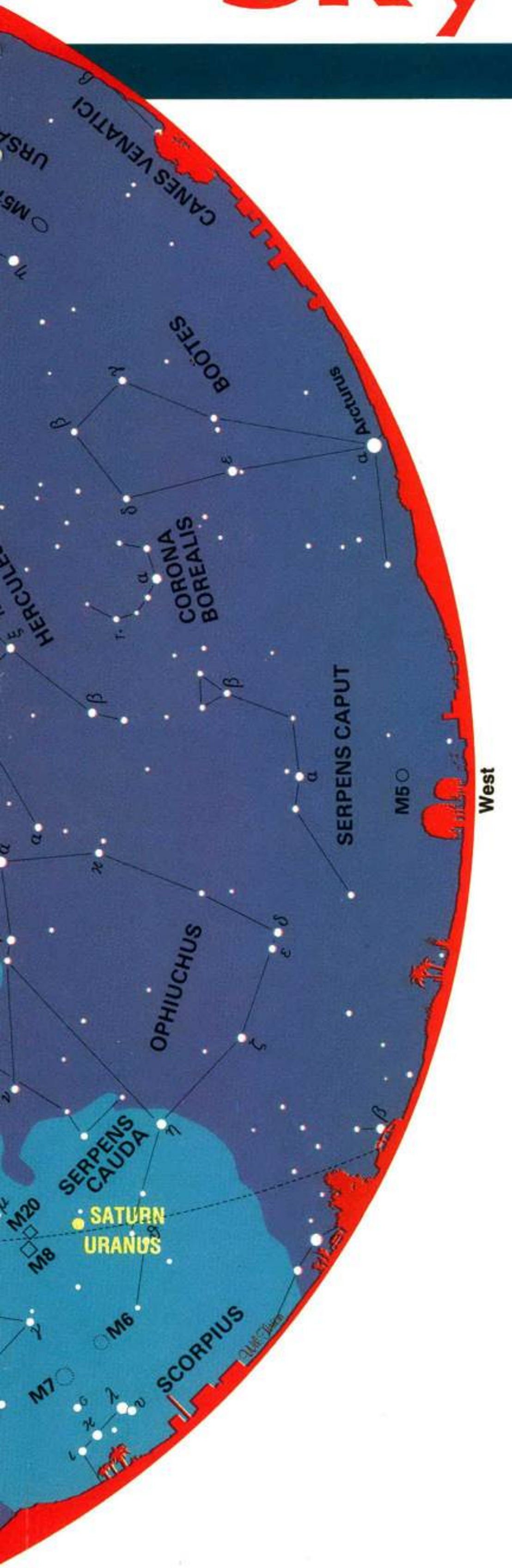
NGC NOTES, Pack of 200	**$9.95**
Pack of 400 **$17.95** Pack of 800	**$32.95**

The all-sky map shows how the sky looks at:
11:30 p.m. on September 1
10:30 p.m. on September 15
9:30 p.m. on September 30
Planets are shown at mid-month


North
South
East
LYNX
AURIGA
Capella
URSA MAJOR
Mizar
M81
M82
CAMELOPARDALIS
URSA MINOR
N. Pole Polaris
PERSEUS
Algol
Pleiades
TAURUS
CASSIOPEIA
884
869
CEPHEUS
DRACO
TRIANGULUM
ARIES
M33
M31
ANDROMEDA
LACERTA
CYGNUS
Deneb
Vega
M57
LYRA
VULPECULA
M27
Ecliptic
PISCES
PEGASUS
DELPHINUS
SAGITTA
M15
Enif
EQUULEUS
Altair
AQUILA
Mira
CETUS
MARS
M11
SCUTUM
M16
M17
M22
AQUARIUS
CAPRICORNUS
PISCIS AUSTRINUS
Fomalhaut
SGP
253
SCULPTOR
SAGITTARIUS
CORONA AUSTRALIS
PHOENIX
MICROSCOPIUM
GRUS
INDUS
TELESCOPIUM
Magnitudes
Sirius
0.0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies

Sky Almanac

SEPTEMBER 1988



Map Art by Wil Tirion

MARS AT ITS VERY BEST

The Red Planet is bigger and brighter in September than it has been for seventeen years. This apparition peaks on September 27, when Mars is high in the sky for Northern Hemisphere observers.

THE BIG, BRIGHT HARVEST MOON

The Full Moon of September 25 is the famous Harvest Moon. Rising just half an hour later each night, the Harvest Moon dominates the early evening sky for several days late this month.

THE PLEIADES COVERED BY THE MOON

On the night of September 1/2, observers throughout North America can watch the waning gibbous Moon pass over the northern part of the bright, dipper-shaped star cluster.

VENUS, THE MOON, AND THE TWINS

The two luminaries of Gemini, Castor and Pollux, are joined early this month by the bright planet Venus. A narrow crescent Moon makes the trio a foursome on the mornings of September 5-7.

TEMPEL 2 REACHES PEAK BRIGHTNESS

The unusual comet Tempel 2 is at perihelion on September 16, and should be bright enough to spot with binoculars or a small telescope in the early evening hours.

Dates and Times

2 Last Quarter Moon, 11:50 p.m. EDT
Pleiades occulted by Moon
Melpomene at opposition

9 The Moon passes 1.0° north of Regulus, 9 a.m. EDT

10 Moon at apogee (252,572 miles from Earth)

11 New Moon, 12:49 a.m. EDT, and annular solar eclipse
Saturn at aphelion

13 The Moon passes 0.6° south of Mercury, noon EDT

15 Mercury at greatest eastern elongation (27°)

16 Comet Tempel 2 at perihelion

17 Ceres at opposition
The Moon passes 0.7° south of Antares, 5 p.m. EDT

18 First Quarter Moon, 11:18 p.m. EDT

22 Autumnal equinox, 3:29 p.m. EDT

25 Full Moon, 3:07 p.m. EDT
Moon at perigee (222,254 miles from Earth)

27 Mars at opposition

Eye on the Sky by Deborah Byrd

MARS SHINES BRILLIANTLY during September, brighter even than in 1986, when Mars (at upper left) easily outshone the stars of Sagittarius and Scorpius.

MARS: BRIGHTEST SINCE 1971

Ask any schoolchild what his or her favorite planet is, and the answer will most likely be Mars. You can impress and amaze this child and any but the most unimaginative adult by pointing Mars out to them in the sky this month.

This mysterious and alluring world is now closer to Earth and brighter in our sky than it has been since 1971. Its brilliance and reddish orange color make it impossible to miss or mistake. Mars shines with a clear, steady, rust-colored light nearly all night throughout the month. It ascends in the east each evening, is high in the south around midnight, and descends in the west as dawn approaches.

Mars is especially close this year because Earth passes between Mars and the Sun around the time that the Red Planet is nearest the Sun in its 2-year orbit. Martian "perihelion," the planet's closest point to the Sun, occurred on August 12. On the night of September 27/28, we pass between the Sun and Mars. Then the planet is at "opposition" and appears directly opposite the Sun in our sky.

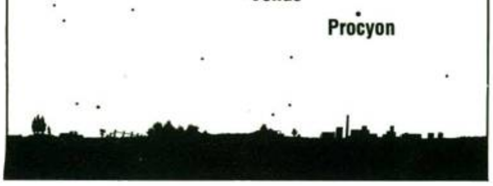
Because perihelion comes before opposition this year, Mars' closest approach to Earth doesn't coincide with opposition. Earth comes closest to the Red Planet on the night of September 21/22, as we are catching up to Mars from behind in our smaller orbit. On that night Mars is slightly more than 35 million miles from Earth. (In contrast, when opposition occurs with Mars at its farthest from the Sun, the distance between our two worlds is close to 60 million miles.)

THE EQUINOX AND AN ECLIPSE

The Sun offers two events for naked-eye observers this month, one special and one annual. First, on September 11, an annular solar eclipse occurs in parts of the Southern Hemisphere. In an annular eclipse the Moon is far enough from Earth that the Moon cannot completely cover the Sun. Instead, a ring of Sun (or annulus) remains visible around the Moon's edge. Although the path of annularity lies mostly in the Indian Ocean, observers in eastern Africa, southern Asia, parts of Antarctica, and most of Indonesia, Australia, and New Zealand can see a partial eclipse.

Second, the September equinox arrives this year at 3:29 p.m. EDT on September 22. That is the instant when the center of the Sun lies on the celestial equator, the imaginary line drawn around the sky directly above Earth's equator. Called the autumnal equinox, this instant marks the first day of fall in the Northern Hemisphere. The Sun is moving southward now and its rays strike the Northern Hemisphere less directly, a sign of the inevitable coming of winter to our half of the globe. In the Southern Hemisphere, meanwhile, people at this month's equinox celebrate the first day of spring.

The day of the equinox is ideal for learning a basic fact about your favorite observing spot. On this day the Sun rises due east and sets due west. Watch the Sun rise or set on September 22, and pinpoint the direction with respect to earthly landmarks. Knowing the cardinal directions at your favorite spot can help you locate objects in the sky from the directions given in Sky Almanac.



VENUS JOINS CASTOR AND POLLUX in early September, and the waning crescent Moon is nearby. The quartet makes a nice grouping in the east an hour and a half before sunrise on September 6.

SHINE ON, HARVEST MOON

The Harvest Moon — the Full Moon that occurs nearest the September equinox — rises at sunset on the evening of September 25. According to folklore, the Harvest Moon is bigger, brighter, and yellower than other Full Moons. It isn't really, but you will still enjoy watching the bloated yellow orb rise early in the evening for a few days around the 25th.

It is the rising time of the Moon that makes the Harvest Moon unique. At this time of year in mid-northern latitudes the Moon's path makes a shallow angle with respect to the eastern horizon in the early evening. From one day to the next the Moon moves its usual distance in orbit around Earth, but this movement doesn't translate to substantial progress eastward among the stars. Instead of rising about fifty minutes later each day, as it usually does, the Moon appears over the eastern horizon only about half an hour later each day for several evenings around Full Moon. The light of the nearly Full Moon used to help farmers bring in their crops because they could work uninterrupted after the Sun had set, hence the name Harvest Moon.

If you note where along the eastern horizon the Harvest Moon rises, you can also see that the Moon comes up progressively farther north for several evenings after the 25th. Furthermore, on the night of the 25th both Mars and the Harvest Moon lie in approximately the same direction in our sky. Look for them about 7° apart in the late evening.

SEPTEMBER'S PLANETS

Saturn, which drew our gaze on early summer evenings with its soft, golden glow, is becoming rather easy to overlook. At magnitude +0.5 in mid-September Saturn is now half a magnitude fainter than it was in June. It can be found low in the south — a steady light in star-cluttered Sagittarius — when night falls. Saturn sets around midnight.

Several other planets outshine Saturn this month, but Saturn is doing its best to appear as bright as it can. Saturn's brightness in our sky depends largely on a feature that cannot be seen without a telescope: the famous ring system. The rings currently appear wide open as seen from Earth and reflect more sunlight than the planet itself, which adds greatly to Saturn's overall brightness.

Mars rises shortly after sunset on September 1 and at sunset later in the month. It is brilliant, fiery red, and visible all night against the background of the nonzodiacal constellation Cetus.

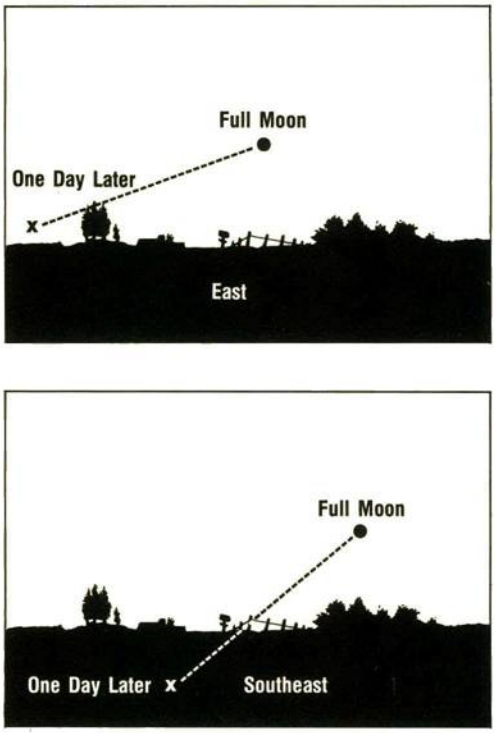
For a few days around its opposition on the night of September 27/28, Mars shines at magnitude −2.8, which makes it even brighter than mighty Jupiter. The Red Planet is closest to Earth six days earlier but shines brightest at opposition because then its illuminated hemisphere faces in our direction.

Mars is not only bright, it also rides high in the sky for observers in mid-northern latitudes. The planet has not been at once so bright and so high in our sky since 1956. And Mars will not be so well positioned in our sky again until 2020.

Jupiter this month rises a couple of hours too late — and falls a couple of tenths of a magnitude too short — to rival Mars at its brightest. The giant planet rises in mid-evening and shines at magnitude −2.6 late in the month.

Jupiter continues to slide between two star clusters — the tiny dipper-shaped Pleiades, or Seven Sisters, and the V-shaped Hyades in the constellation Taurus. The brightest star in the Hyades, Aldebaran, is not a cluster member. It's simply a "foreground star," located along the same line of sight as the cluster but much closer to Earth. During the first part of September you can watch Jupiter edge closer to Aldebaran. On September 24, the planet stops this eastward drift and begins moving away from the star. The beginning of "retrograde," or western, motion for Jupiter is a prelude to the planet's opposition, which occurs in November.

Venus rises nearly four hours before the Sun does and stands high



THE HARVEST MOON is renowned because it rises only half an hour later each day, the result of the shallow angle the Moon's path makes with the horizon (top). In a more typical month (June, shown in an equivalent view above) the Moon moves at a steeper angle to the horizon and moonrise is about fifty minutes later each day.

in the east at dawn. At magnitude −4.2 the planet named for the goddess of love outshines both Mars and Jupiter. Together, the three worlds are magnificent in this month's predawn sky.

The two stars close to Venus early in the month are Castor and Pollux in the constellation Gemini. They appear closest to being on a straight line with the planet on the morning of September 7. The waning crescent Moon is also nearby from September 5 to 7, which makes a pretty grouping in the morning sky. Later in the month watch with binoculars as Venus sweeps to the south of the star cluster called Praesepe, or the Beehive, in the constellation Cancer.

In case you're wondering where it went, Mercury has been in the evening sky since last month. It is very low in the west-southwest all this month too, and it is difficult to see by any but the most diligent binocular observers.

SEPTEMBER'S STARRY SKY

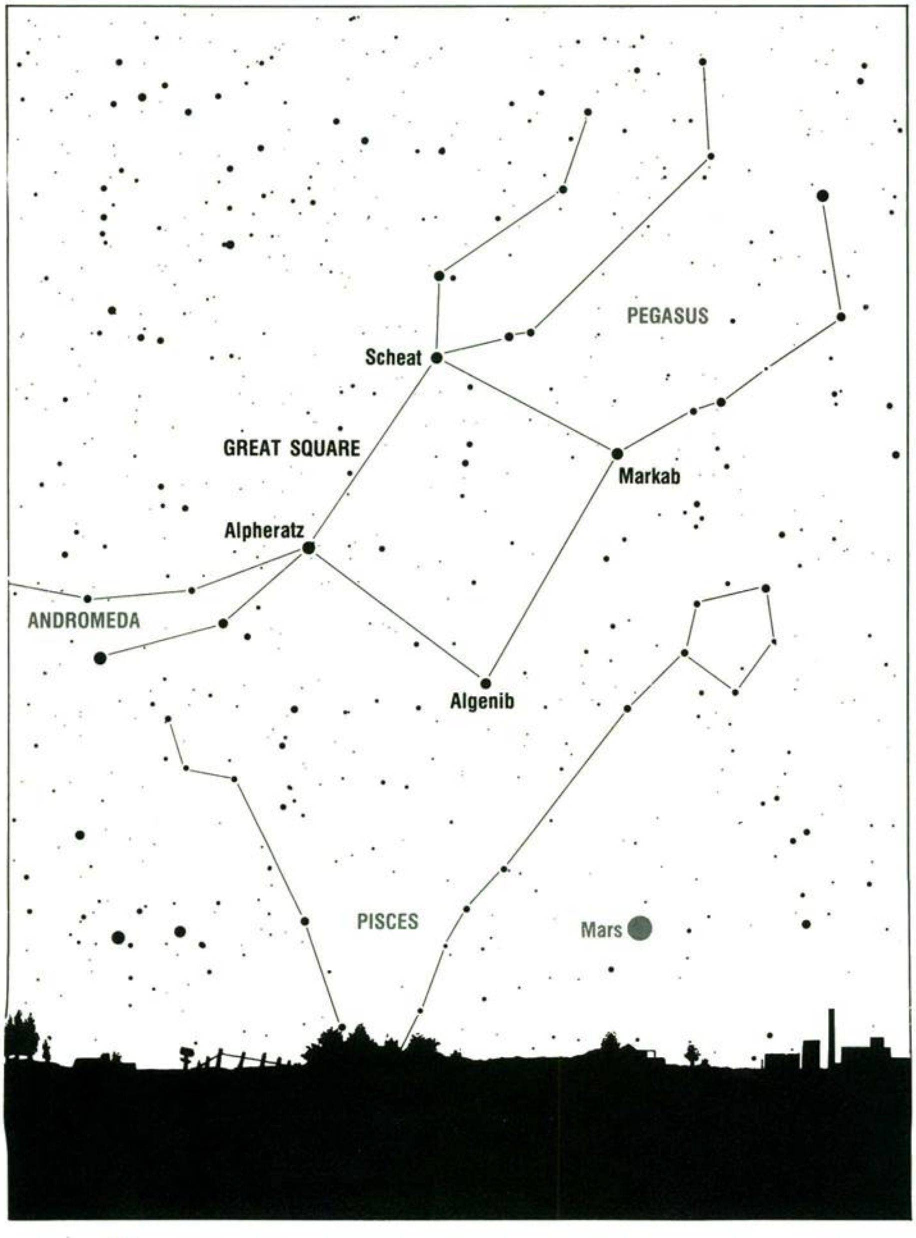
In the same general region of the sky that Mars and the Harvest Moon occupy on September 25, you will find a large, square pattern of stars. The Great Square, an asterism in the constellation Pegasus the Flying Horse, is one of the sky's most recognizable figures. The four stars marking its corners are about equal in brightness and the sides are approximately equal in length. In years to come, when Mars has faded and moved to some other part of the sky, the Great Square will be there — a fixture of early autumn and a reminder of cooler days ahead.

The four stars marking the corners of the Square are named Scheat, Markab, Algenib, and Alpheratz. Alpheratz used to have the distinction of belonging to two constellations: Pegasus and neighboring Andromeda. Now, however, a star can belong to only one constellation, and this star belongs officially to Andromeda.

The Great Square is located in a star-poor region of the sky. Nevertheless, it's fun to count stars inside the Square. Such counts can serve as tests of the sharpness of your vision and the clarity of the autumn night air.

The brightest stars within the Square's boundaries are no brighter than magnitude +4.4. You might be able to spot them on exceptionally good nights from some suburbs. From the country on a very dark night you might see several dozen stars within the Square. It's said that Julius Schmidt — a nineteenth-century astronomer renowned for his eyesight — saw 102 stars with his naked eye within the Square! How many can you see? ☐

THE GREAT SQUARE OF PEGASUS rises as a diamond-shaped asterism in the east on September evenings. This year the ruddy glow of Mars adds extra color and light to this region.



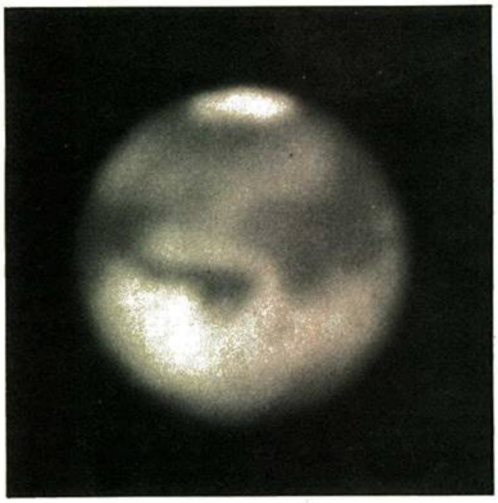
Through the Eyepiece by Rick Shaffer

MARS — THE MAIN EVENT

Mars reaches several milestones in September — it is closest to Earth, opposite the Sun in the sky, and arrives at its winter solstice — and observers on Earth can get in on the celebration. The Red Planet makes its closest approach to Earth for this apparition on the night of September 21/22. At a distance of only 36.5 million miles, Mars appears larger — with an apparent diameter of 23.8″ — than at any time since 1971. We have to wait until opposition six days later to see Mars at its brightest, however. On the night of September 27/28, the Red Planet shines at magnitude −2.8, and it either equals or outshines Jupiter for the last twenty-five days of September. And on September 11, Mars reaches its winter solstice. On that date the Sun is at its southernmost point in Mars' sky and summer begins in the Martian southern hemisphere.

As September progresses, telescopic observers can view Mars earlier in the evening. At the beginning of the month Mars is above most of the "horizon murk" by 10:30 p.m. local daylight time, and by the end of the month you can begin observing Mars as early as 8:30 p.m. Your view of the planet will get better, however, if you wait for Mars to rise higher in the sky. Your best view should come when Mars transits the meridian (around 1 a.m. daylight time at the end of the month) and is thus at its highest elevation.

Mars has always been particularly fascinating to planetary observers because it is the only planet in the solar system with surface features we can reasonably observe. But surprisingly, many of the Martian features we can observe and photograph through our telescopes simply disappear when spacecraft photograph Mars close-up. The dark gray-green "features" we see from Earth appear darker than surrounding areas because they are rougher, or because they are slightly redder and our eye-brain combination adds contrast and shifts the color toward the green in such situations. The Martian features that change size and brightness appear to be caused primarily by deposits of fine material left by ferocious dust storms.



OBSERVE MARS' SOUTH POLAR CAP and other southern hemisphere features this month as Mars tilts its south pole toward us.

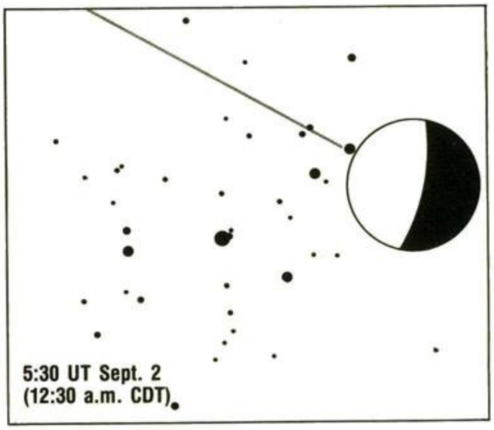
SATURN'S RINGS AT MAXIMUM TILT

Saturn reaches two milestones itself in September. On September 11, Saturn is at aphelion, its farthest point from the Sun during its 29.5-year orbit, at a distance of 930 million miles. And on September 25, the north side of Saturn's rings is tilted its maximum toward Earth for this orbit: just less than 27°. After the 25th, the inclination of the rings decreases very slowly; the rings will not appear edge-on until 1996.

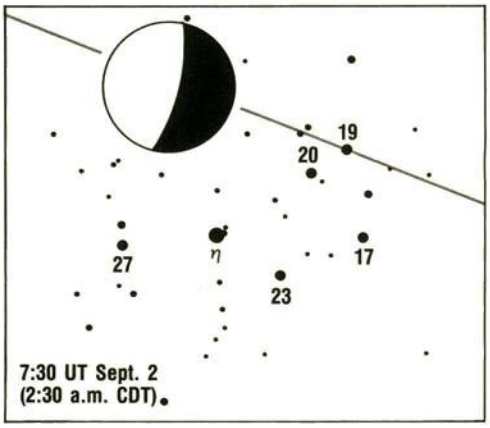
September is the last month to observe Saturn while it is reasonably high in the sky. Look for it in the southwest as soon as the sky gets dark. Because Saturn is well past opposition, the planet's apparent size shrinks this month. The highly tilted rings diminish from 38.7″ across on the 1st to 36.9″ across on the 30th, while the equatorial diameter shrinks proportionately, from 17.1″ to 16.3″.

If you encounter a night of truly superb seeing, you should be able to spot both major divisions in Saturn's rings (the dark Cassini Division is far easier to see), as well as some irregularities in the planet's atmospheric belts. If you see details this subtle, don't fail to turn your attention to Titan, Saturn's largest satellite. On a night of superb seeing in 1982 I resolved Titan's tiny orange disk with a 17.5-inch Newtonian reflector at a magnification of 235x.

Titan — an 8.4-magnitude orange object that can appear up to 3.3′ from Saturn — is an easy target for a 2-inch or larger telescope. Four other Saturnian satellites are bright enough to spot quite easily in 6-inch or larger scopes. In order outward from Saturn these are Tethys (magnitude 10.3), Dione (10.4), Rhea (9.7), and Iapetus. Iapetus is a special case, because it is five times brighter at western elongation (magnitude 10.1) than at eastern elongation (magnitude 11.9). This month Iapetus is brightest on September 6, when it is about 9.5′ west of Saturn. Use the charts on page 62 to find Saturn's satellites at the beginning of the month when

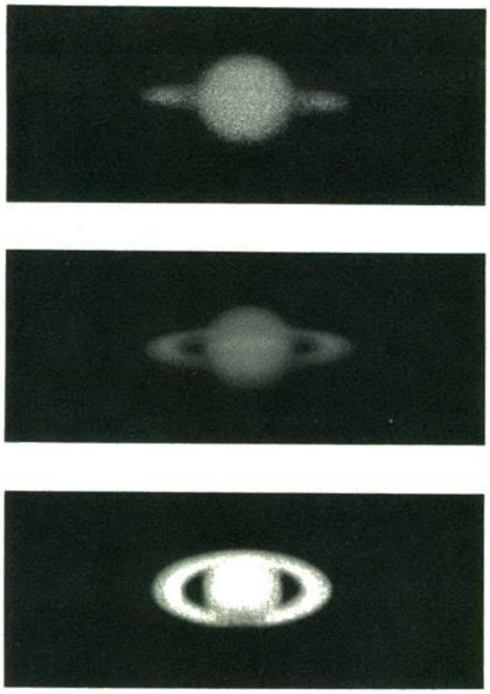


5:30 UT Sept. 2
(12:30 a.m. CDT).



7:30 UT Sept. 2
(2:30 a.m. CDT).

SEVERAL OF THE SEVEN SISTERS will disappear the night of September 1/2 as the Moon occults the Pleiades for North American observers. This is the view from Kansas City; elsewhere the Moon follows a slightly different path at slightly different times.



SATURN'S RINGS appear wide open this month, the culmination of an eight-year cycle. In that time the rings have gone from edge-on through a 5° tilt (top), an 11° tilt (middle), and a 25° tilt (above), to this month's 27° tilt.

SATURN'S MOONS are easy to find, if you know where to look. These drawings show the major moons at 11 p.m. EDT, 10 p.m. CDT, 9 p.m. MDT, and 8 p.m. PDT (3 UT the next day).

the Moon is out of the evening sky.

THE MOON OCCULTS THE PLEIADES

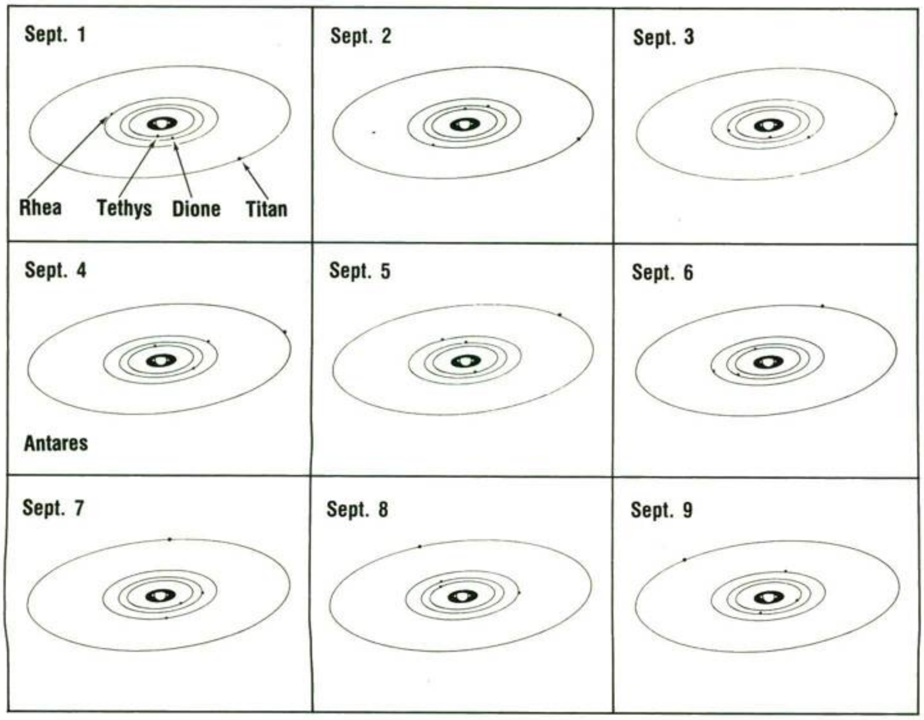
Although the Moon passes in front of the Pleiades every month this year as viewed from somewhere on Earth, the occultation on the night of September 1/2 is especially well suited for North American observers. The middle of the occultation occurs early on the morning of September 2 for East Coast observers, around midnight for those on the West Coast, and in early evening on September 1 for Alaskan observers. Viewing the nearly third-quarter Moon as it strolls among the Seven Sisters will be aesthetically pleasing, but the 58 percent-illuminated Moon will make seeing the fainter Pleiads quite difficult. Use this opportunity to put the relative sizes of the Moon and the Pleiades in perspective; the result may well surprise you.

TEMPEL 2 AT ITS BRIGHTEST

Comet Tempel 2 reaches perihelion on September 16, and is low in the southwestern sky just after the end of twilight. The comet spends the first twenty days of the month in southern Ophiuchus and then passes into Sagittarius on the 21st. Plan to observe Tempel 2 before mid-month, because the Harvest Moon makes the last fifteen days of the month poor for observing a comet in the evening sky.

Tempel 2 was discovered in 1873 by French observer William Tempel, and it has been observed on eighteen separate apparitions counting this one. For this reason Tempel 2's unusual behavior before and after perihelion is well known. Relative to most other periodic comets, Tempel 2 brightens very rapidly just before perihelion and fades very slowly after perihelion passage. In fact, an average periodic comet with the same orbit as Tempel 2 would remain at a nearly constant brightness from July 1 to October 1, whereas Tempel 2 may brighten by five magnitudes in the same time.

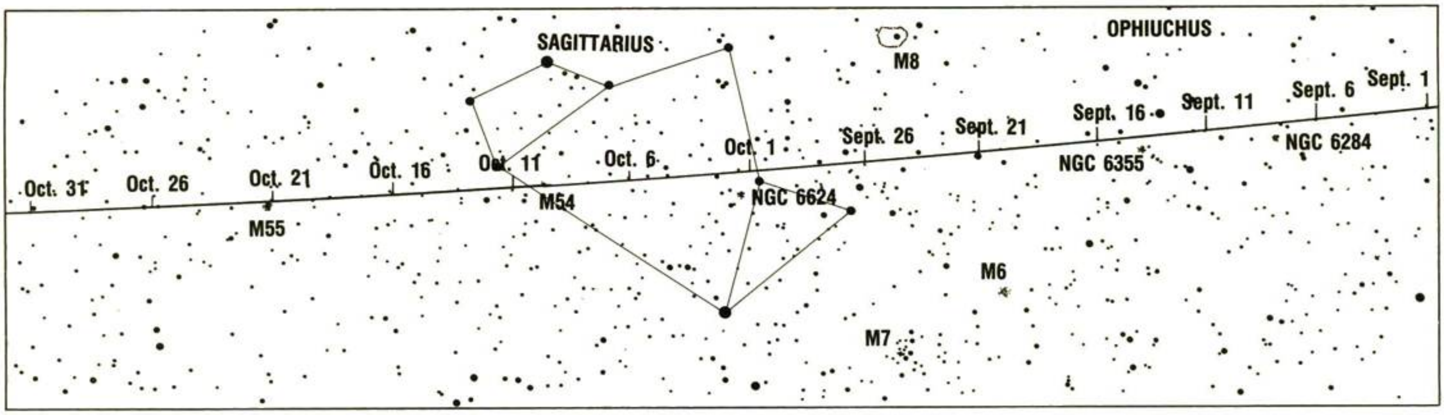
Estimates of Tempel 2's brightness vary, though not as much near perihelion as they did a few months ago. Most astronomers predict that the comet should reach 8th magnitude at peak brightness, which would make Tempel 2 visible in 4-inch and larger telescopes during the first half of September and October and possibly in 7x50 binoculars under a dark sky. Use the finder chart on page 63 to locate this unusual comet.



SEPTEMBER'S PLANETS

Mercury reaches greatest eastern elongation on September 15, and is nearly 27° from the Sun on that date. However, this month's evening apparition is the worst of the year because the ecliptic nearly parallels the western horizon. Thus, Mercury's large distance from the Sun does not translate into that much elevation above the horizon, and the innermost planet is mostly lost in the solar glare.

Your best chance of finding Mercury this month occurs on the evening of the 13th. The two-day-old Moon passes just 0.6° south of Mercury earlier in the day, and North American observers can glimpse Mercury just below and to the right of the Moon after sunset. Use binoculars to witness this minor spectacle.



The morning sky in September continues to be dominated by Venus. The bright planet rises a bit less than four hours before the Sun does early in the month and three-and-a-half hours before sunrise at the end of September. Venus begins the month at magnitude −4.3 in Gemini and fades only to −4.1 as it passes into Leo at the end of the month. During the same time Venus' disk shrinks from 21″ to 17″ across. If you've been faithfully making drawings of Venus' appearance in your telescope, this is the month you'll begin to notice less of a change in the phase of the planet.

The Moon passes between Earth and the Sun on September 11. However, because the Moon is nearly at apogee, its apparent diameter is insufficient to completely cover the Sun. Thus we have an annular eclipse of the Sun, in which a ring, or annulus, of Sun surrounds the Moon. The path of the shadow begins at sunrise on the east coast of Africa, runs east and then southeast through the Indian Ocean, and ends between New Zealand and Antarctica. Few people will have the opportunity to view annularity, although people in areas surrounding the path can see a partial eclipse.

Jupiter spends all of September in Taurus. The planet begins the month moving east, becomes stationary on the 24th, and then begins a slow, westward motion. Jupiter is approaching opposition in late November, so this month its apparent diameter and brightness increase. Its disk grows from 40.7″ to 44.6″ during September as its magnitude brightens from −2.4 to −2.6. Jupiter rises before midnight local daylight time at the beginning of the month and by mid-evening at the end of the month. It will be a showpiece between the Pleiades and Hyades star clusters.

Uranus and Neptune continue to move in concert with Saturn this month, so you might try viewing them at high power if you notice that the seeing is excellent while viewing Saturn. Because these are the most remote of the gas giant planets, they are also the coldest, and they never reveal anything but tiny, featureless, blue-green disks in backyard telescopes.

SEPTEMBER'S ASTEROIDS

Asteroid 1 Ceres reaches opposition on the night of September 16/17. Ceres is the largest of the known asteroids at just over 600 miles in diameter and is two-thirds bigger than the next largest asteroid, 2 Pallas. Although 4 Vesta is brighter than Ceres, Ceres was discovered first, on January 1, 1801, by Italian astronomer Giuseppe Piazzi. To find this 7.2-magnitude object, refer to the table at right and plot these positions on your star atlas.

Although not a member of the "Gang of Four" — the first four asteroids discovered and known best — 18 Melpomene is the third-brightest asteroid of 1988 and reaches opposition on September 2. Use the table at right and plot Melpomene's positions on a good star atlas to locate the 7.9-magnitude object. (Asteroid positions are given for 0 UT.) ☐

COMET TEMPEL 2 BRIGHTENS to 8th magnitude in late September and early October. Use the map above or the coordinates below to find the periodic comet as it moves through Ophiuchus and Sagittarius. (Positions are given for 0 UT.)

Date	R.A. (2000)	Dec.
Sept. 1	16h45.7m	−22°06′
Sept. 6	16h59.7m	−23°42′
Sept. 11	17h14.6m	−25°11′
Sept. 16	17h30.5m	−26°32′
Sept. 21	17h47.3m	−27°44′
Sept. 26	18h04.8m	−28°45′
Oct. 1	18h22.9m	−29°34′
Oct. 6	18h41.4m	−30°11′
Oct. 11	19h00.4m	−30°35′
Oct. 16	19h19.5m	−30°47′
Oct. 21	19h38.6m	−30°46′
Oct. 26	19h57.6m	−30°32′
Oct. 31	20h16.4m	−30°07′

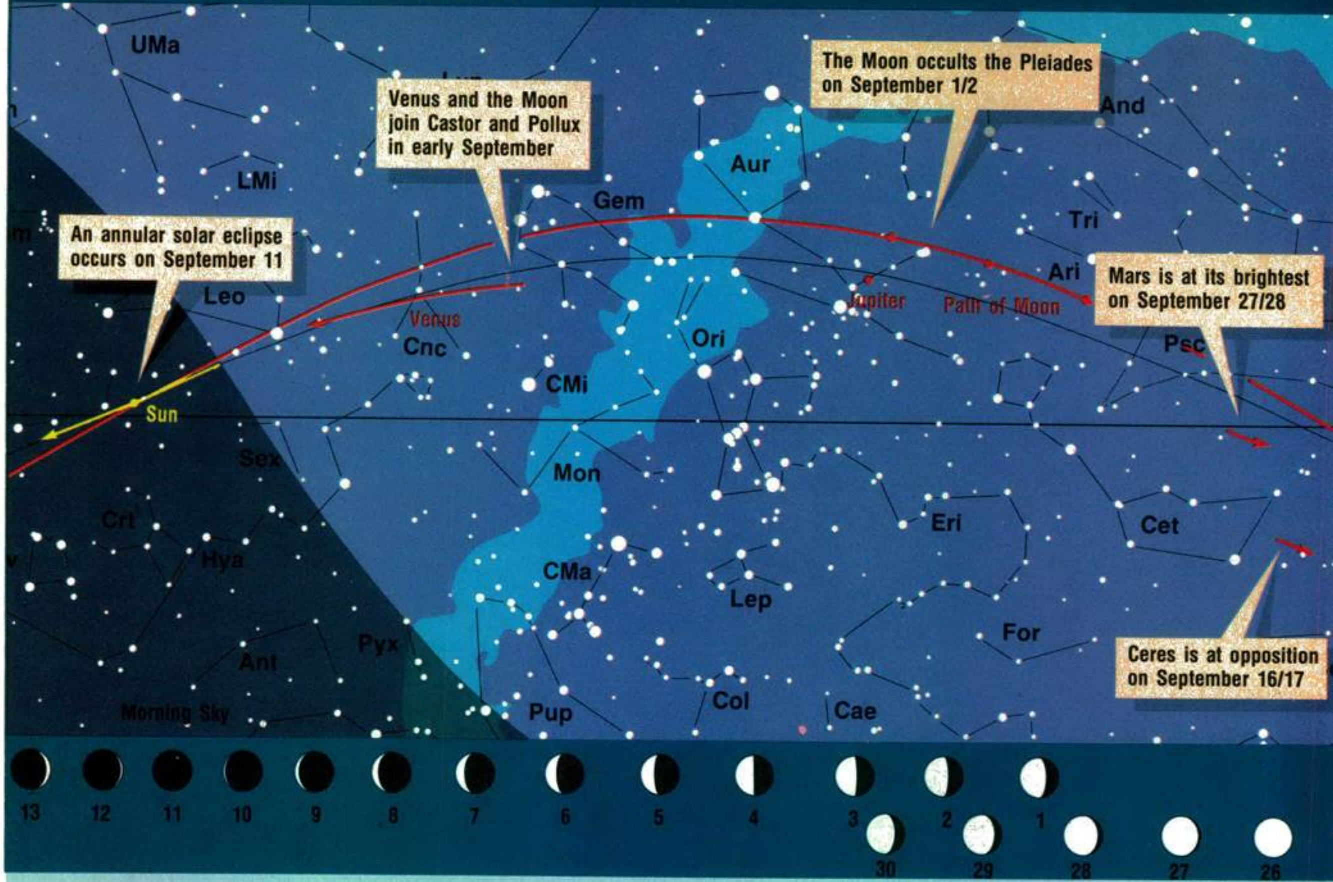
CERES' POSITIONS

Date	R.A. (2000)	Dec.
Sept. 1	0h18.6m	−15°06′
Sept. 7	0h14.5m	−15°44′
Sept. 13	0h09.8m	−16°20′
Sept. 19	0h04.9m	−16°51′
Sept. 25	23h59.8m	−17°17′
Oct. 1	23h54.9m	−17°37′

MELPOMENE'S POSITIONS

Date	R.A. (2000)	Dec.
Sept. 1	22h54.3m	−10°46′
Sept. 7	22h50.4m	−12°12′
Sept. 13	22h46.6m	−13°33′
Sept. 19	22h43.2m	−14°47′
Sept. 25	22h40.4m	−15°53′
Oct. 1	22h38.9m	−16°43′

The Solar System September 1988


UMa
LMi
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Gem
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Tri
Ari
Psc
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Venus
CMi
Ori
Jupiter
Path of Moon
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Sex
Mon
Crt
Hya
CMa
Lep
Eri
Cet
For
Pyx
Ant
Pup
Col
Cae
Morning Sky
13
12
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4
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1
30
29
28
27
26

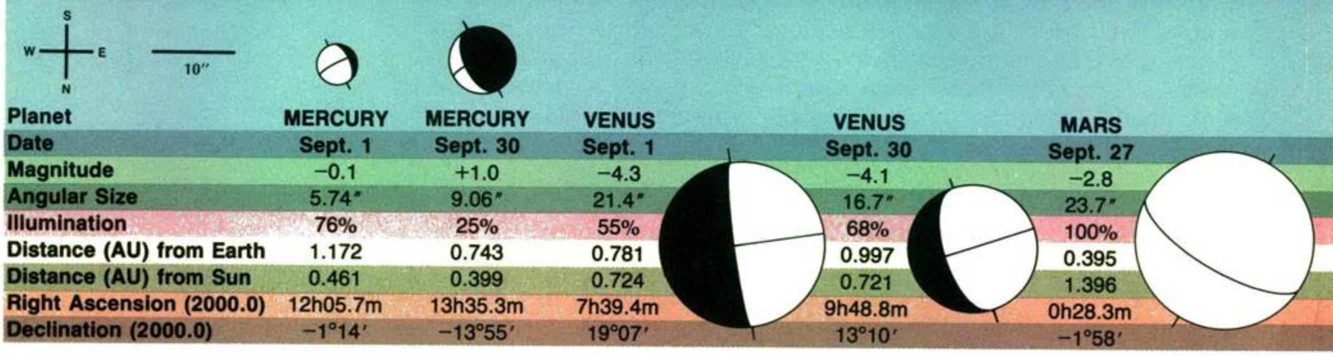
Venus and the Moon join Castor and Pollux in early September

The Moon occults the Pleiades on September 1/2

An annular solar eclipse occurs on September 11

Mars is at its brightest on September 27/28

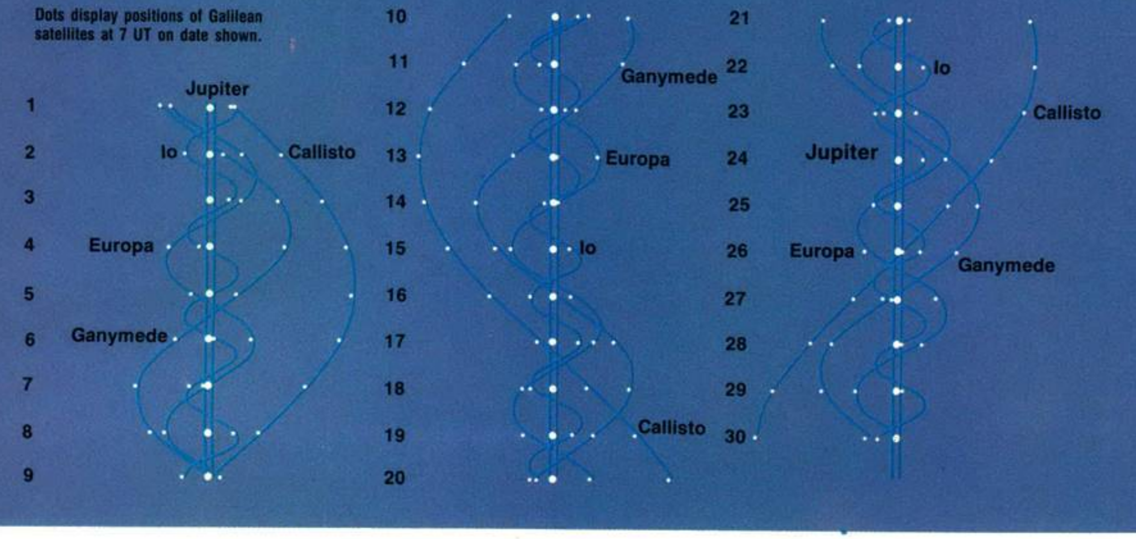
Ceres is at opposition on September 16/17

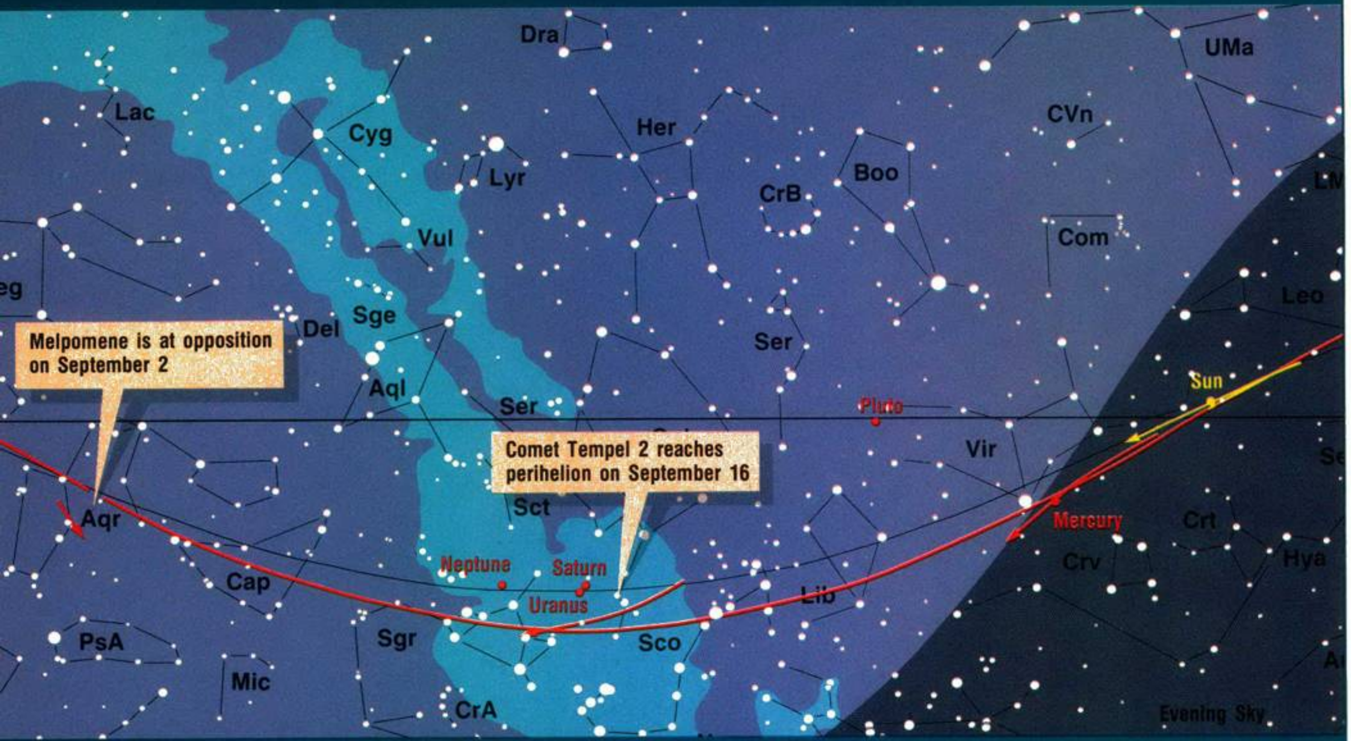


Planet	MERCURY	MERCURY	VENUS	VENUS	MARS
Date	Sept. 1	Sept. 30	Sept. 1	Sept. 30	Sept. 27
Magnitude	−0.1	+1.0	−4.3	−4.1	−2.8
Angular Size	5.74″	9.06″	21.4″	16.7″	23.7″
Illumination	76%	25%	55%	68%	100%
Distance (AU) from Earth	1.172	0.743	0.781	0.997	0.395
Distance (AU) from Sun	0.461	0.399	0.724	0.721	1.396
Right Ascension (2000.0)	12h05.7m	13h35.3m	7h39.4m	9h48.8m	0h28.3m
Declination (2000.0)	−1°14′	−13°55′	19°07′	13°10′	−1°58′

Jupiter's Moons

Dots display positions of Galilean satellites at 7 UT on date shown.




Dra
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Cyg
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CVn
Lyr
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Leo
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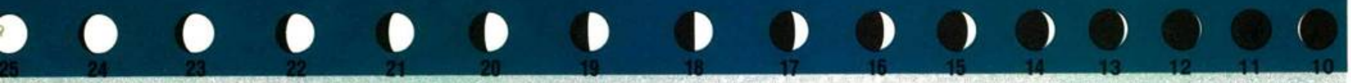
Ser
Aql
Ser
Sun
Pluto
Vir
Se
Sct
Aqr
Mercury
Crt
Neptune
Saturn
Crv
Hya
Cap
Lib
Uranus
PsA
Sgr
Sco
A
Mic
CrA
Evening Sky

Melpomene is at opposition on September 2

Comet Tempel 2 reaches perihelion on September 16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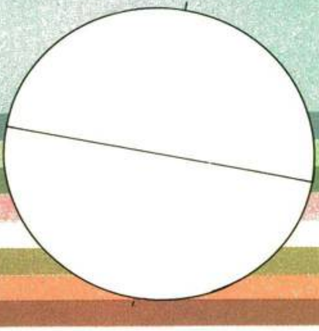
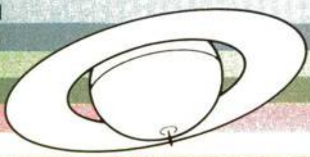
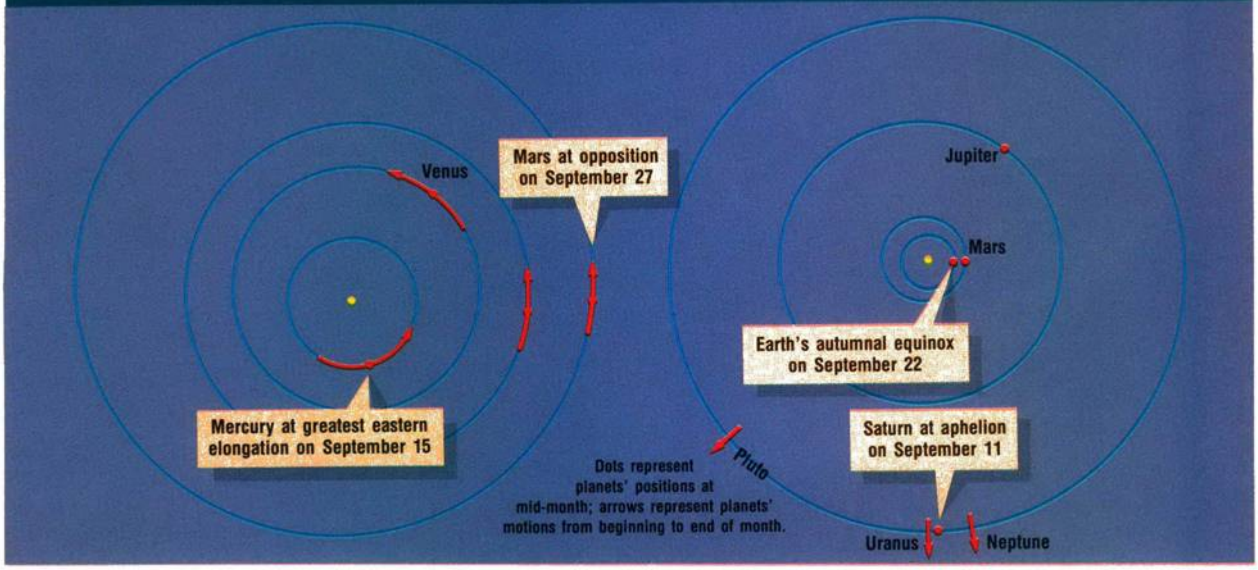




JUPITER Sept. 15	SATURN Sept. 15	URANUS Sept. 15	NEPTUNE Sept. 15	PLUTO Sept. 15
−2.5	+0.5	+5.7	+7.9	+13.8
42.6″	16.7″	3.7″	2.2″	0.1″
99%	100%	100%	100%	100%
4.627	9.928	19.187	29.946	30.296
5.005	10.044	19.295	30.222	29.662
4h17.8m	17h43.9m	17h48.0m	18h32.8m	14h53.4m
20°21′	−22°28′	−23°38′	−22°16′	−0°14′

The Planets in Their Orbits


Venus
Jupiter
Mars
Pluto
Uranus
Neptune

Mars at opposition on September 27

Mercury at greatest eastern elongation on September 15

Earth's autumnal equinox on September 22

Saturn at aphelion on September 11

Dots represent planets' positions at mid-month; arrows represent planets' motions from beginning to end of month.

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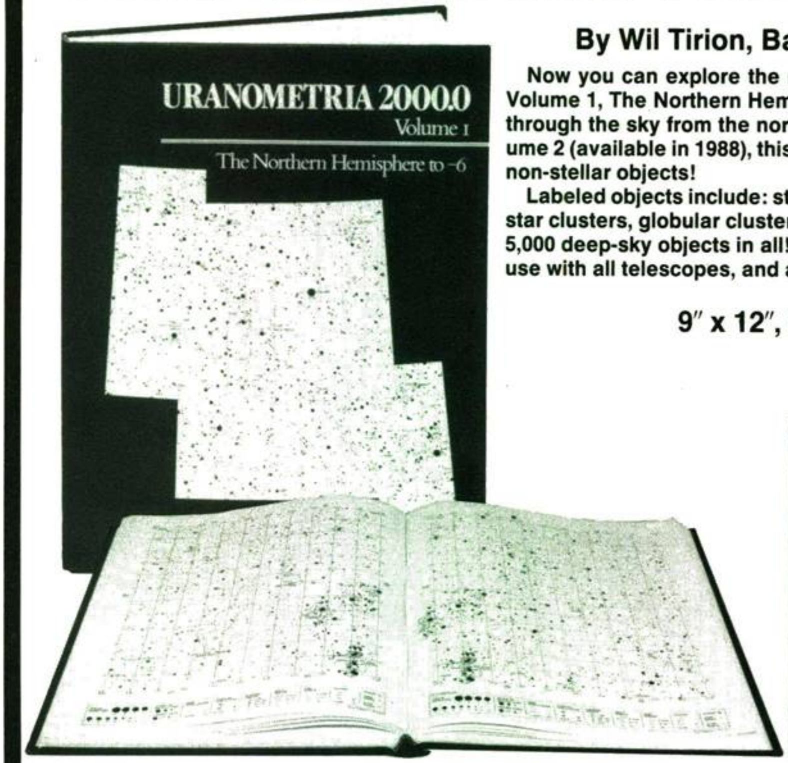
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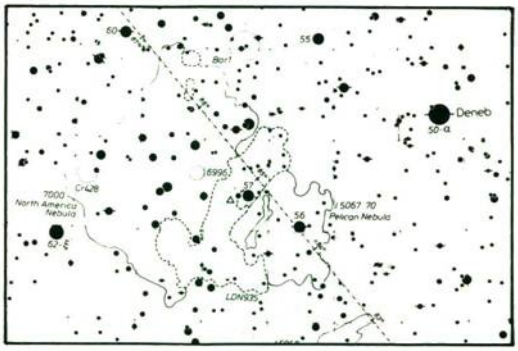
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55
Bar1
Deneb
50-α
6996
Cr428
7000
North America Nebula
57
56
5067 70
Pelican Nebula
62-ξ
LDN935

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NELSON
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CHANG-DIAZ
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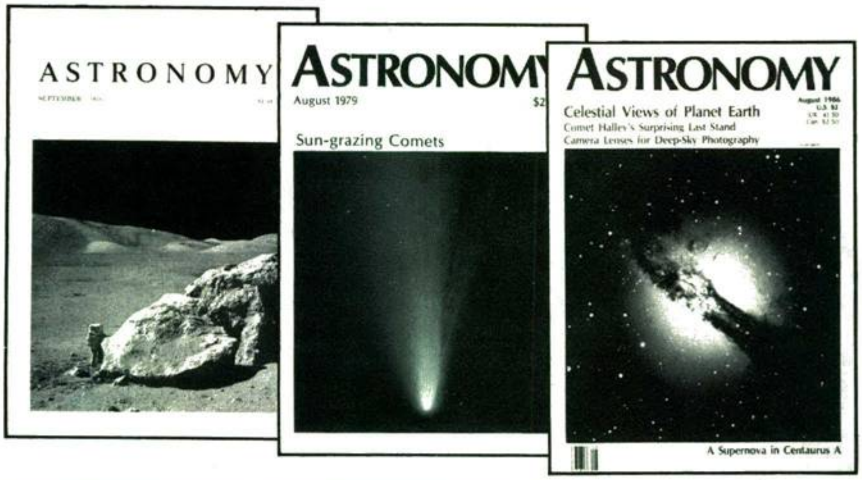
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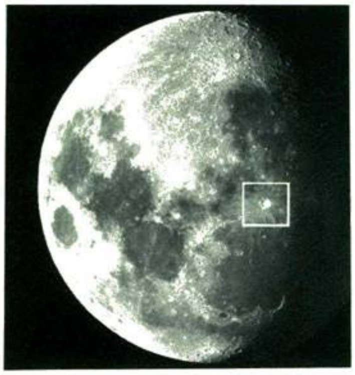
by Michael T. Kitt

Anyone with a telescope can explore the wonders of the Moon's most magnificent crater, and in the imagination at least, make that quarter-million-mile journey to stand on the lofty ramparts and gaze spellbound into the crater's depths.

Created by a colossal impact 800 million years ago, Copernicus crater offers more rich detail than you can find in almost any other lunar feature. It is an outstanding object for night-by-night scrutiny. In the first place, Copernicus' relative youth insures that all the crater's features are sharply defined and well preserved. (An age of 800 million years may not sound young, but for the Moon it is.) Second, Copernicus' prominent placement on a smooth, dark plain displays the crater clearly without the confused jumble of overlapping features you would find if Copernicus lay in the southern highlands. Last, its location near the center of the Moon's disk makes Copernicus visible at convenient hours when the Moon is high in the sky.



NINE DAYS after New Moon, Copernicus (box) lies near the sunrise terminator. (South at top.)

Copernicus measures 60 miles from rim to rim. To put that in earthly terms, you could drop the entire state of Rhode Island into the crater and have room to spare. Its generally flat floor is 36 miles across; its walls average 25 miles wide and rise about 11,800 feet above the crater floor, with the highest peaks in the west (12,600 feet) and the lowest in the south (6,300 feet). In the south-central part of the floor a tangled group of peaks reaches elevations of about 1,500 feet. As seen from outside, the crater walls climb in a gentle 3° slope to the rim, which is about a mile and a half higher than the surrounding plains. The inside contours are steeper and more rugged than the outside (see the profile on the opposite page).

Lunar Sunrise

Tonight is the ninth evening after New Moon. As the terminator (the line dividing lunar night from day) crawls westward at a slow walk, it passes onto the western hemisphere of the Moon, a region of flat lava plains — Oceanus Procellarum, Mare Imbrium, Mare Nubium, and Mare Humorum.

Long before the morning terminator reaches Copernicus, while it is still night on the lower slopes, the highest peaks on the rim are catching the first rays of the rising sun. Forming a broken, irregular ring of jewels, the brightly lit peaks trace the hexagonal outline of the still-hidden crater. Over several hours you will see the illuminated points slowly grow wider and eventually merge to form a ring of light encircling a deep pool of shadow.

Sunrise is the best time to look for the secondary craterlets that radiate outward from Copernicus. These tiny craters were made when blocks of rock were hurled high into the lunar sky by the impact that created Copernicus. Raining down on the landscape, the blocks made shallow craters that can be seen best with the grazing light of dawn or dusk. A few are arrayed in a herringbone pattern, with the "V" always pointing back towards Copernicus. At rare moments of perfect seeing, what seems to be hundreds of craterlets will suddenly pop into view, and the effect is breathtaking.

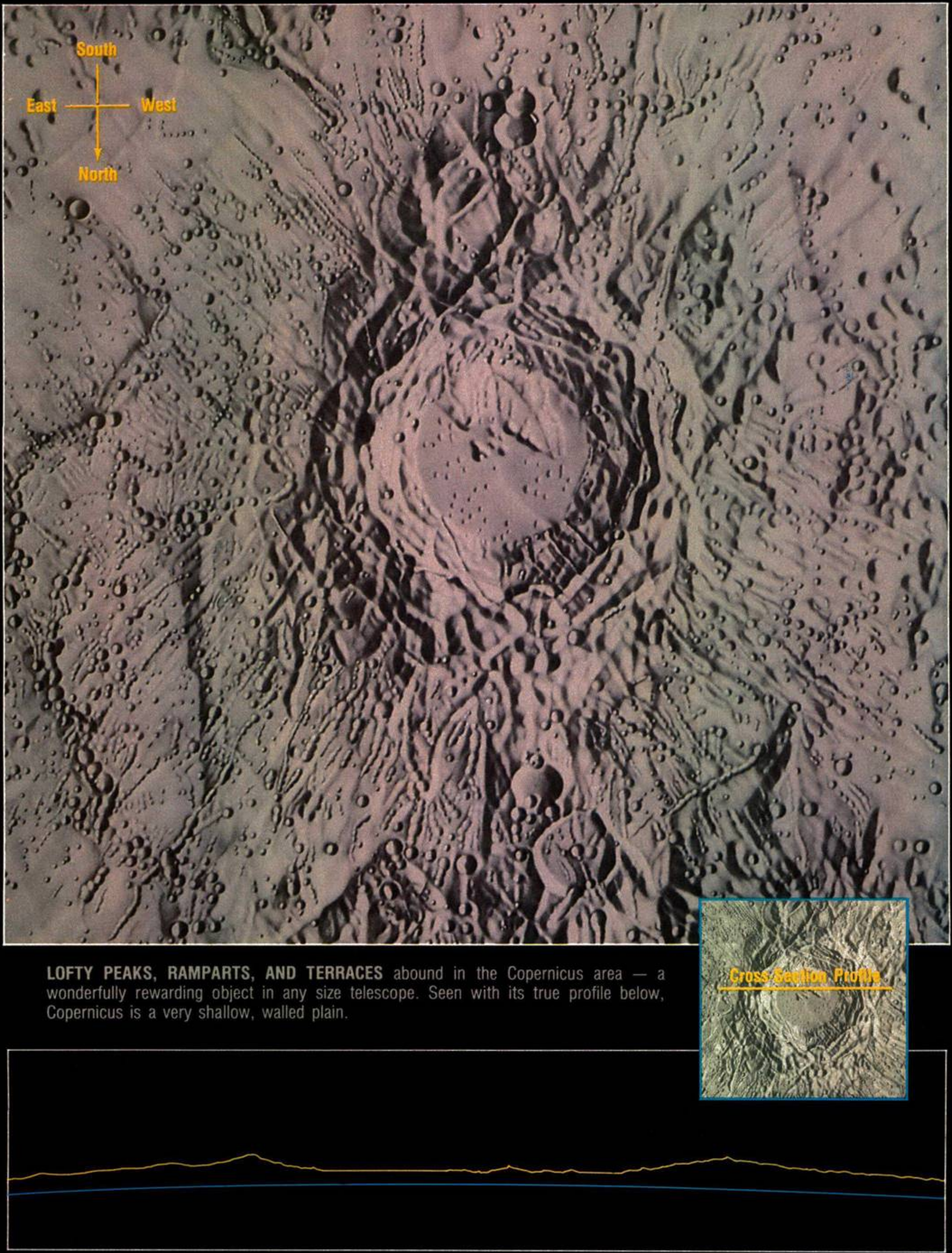
A few hours later the terminator bisects Copernicus, and on the eastern side you can see the ropy-textured, hummocky ejecta blanket that surrounds the crater. The twisted, tortured appearance of this landscape bears evidence of the violent outflow of gas and debris that surged from the impact at ground level.

Either tonight or tomorrow is the time to explore the terraces and ravines on the inside of the western wall. With their concentric shape a dead giveaway, the terraces are huge landslides, where miles-long portions of the inside wall collapsed after the crater was formed. Terraces may have slumped while the dusty explosion cloud still hung over the site or they could have formed later when moonquakes from other impacts shook the Copernicus region. At high power you will see an incredible wealth of detail in the terraces that slowly changes with the lighting condition.

Early Morning Light

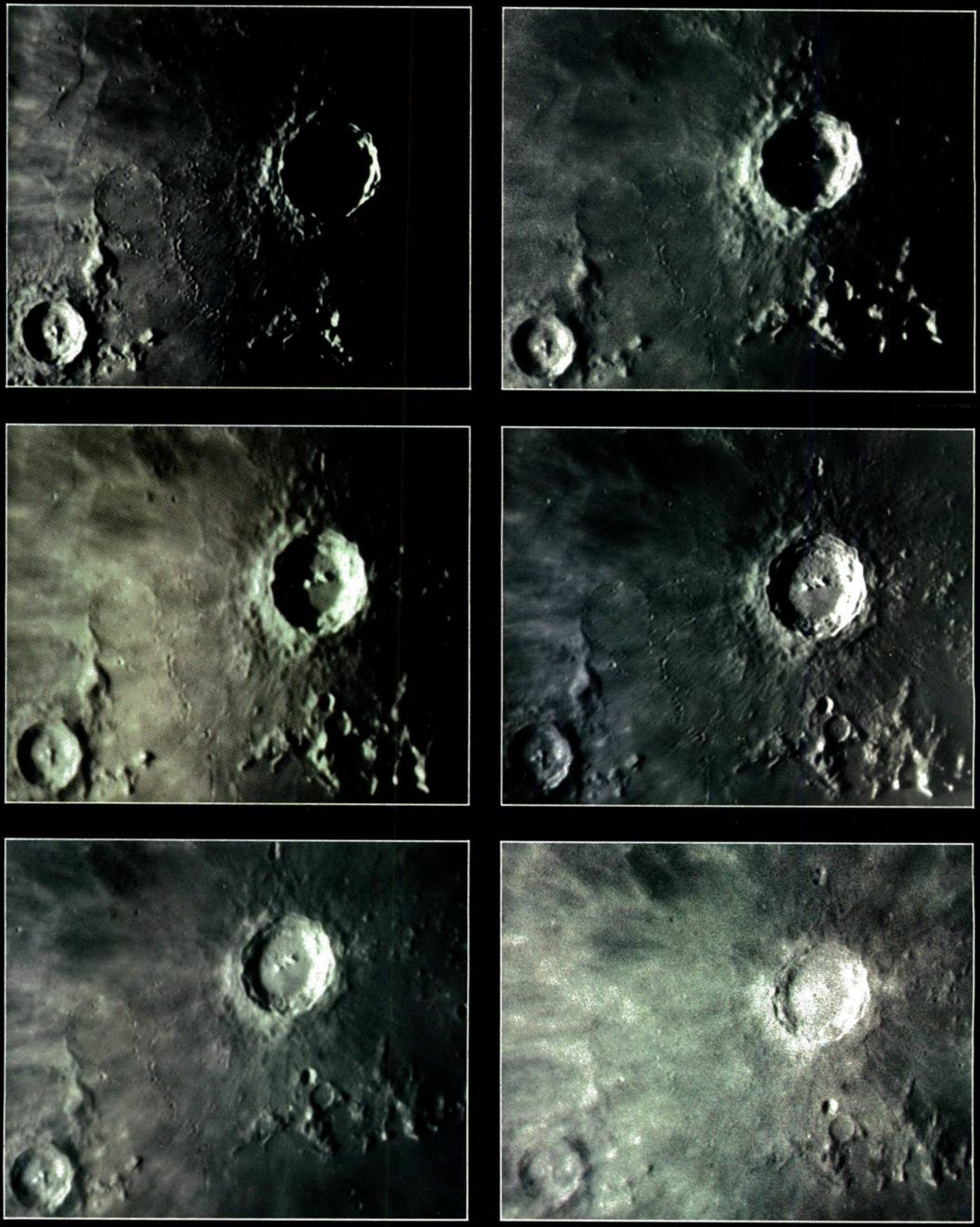
Ten evenings after New Moon, sunlight is streaming into the crater and illuminating the three main central peaks. If your timing is right, you may catch this scene just as the first rays of daylight touch the tips of

THE MOON'S MOST MAGNIFICENT CRATER?


South
East
West
North
Cross-Section Profile

LOFTY PEAKS, RAMPARTS, AND TERRACES abound in the Copernicus area — a wonderfully rewarding object in any size telescope. Seen with its true profile below, Copernicus is a very shallow, walled plain.

FOLLOWING THE PLAY OF SUNLIGHT



THE FIRST RAYS OF MORNING PAINT Copernicus with soot and whitewash. With the Sun low in the lunar sky, your telescope reveals every bump and dip clearly, but as the long lunar morning crawls toward Full Moon, shadows retreat and the crater's varied topography appears to flatten. The photos, beginning at top left, span the interval between local sunrise and two days before Full Moon.

these peaks. (Some months, this moment occurs when the Moon is facing the other side of the Earth.) As you saw with the rim peaks, the central hills on the crater floor will first show as tiny, starlike points of light within the largely darkened bowl of Copernicus. It is fascinating to watch the peaks gradually appear as lunar dawn progresses. Meanwhile, scanning at lower magnification across the landscape to the southeast of the crater will show the ray system becoming more prominent, although its full splendor will not be attained for several days yet.

On the third evening, the eleventh since New Moon, the floor of Copernicus is fully revealed. Note the striking differences in texture between the northern and southern portions. The floor northeast of the central peaks has a lower elevation and appears quite smooth and featureless even at moderate power, while the roughness of the southern area is immediately apparent. Several low hummocks seem to form a link between the southern wall and the central hills.

More changes are apparent on succeeding nights. Now the terraces on the inside of the eastern wall are picked out in light and shadow. Layer upon layer, these rockslides lead down to the crater floor like a giant staircase. Outside the rim, watch the sunlight as it highlights the hummocky terrain of the ejecta blanket. The coarsest deposits extend about one crater-diameter away from the rim, but radial gouges and ridges and chains of craterlets can be traced at least twice that far.

In the Noonday Glare

As Full Moon approaches, Copernicus brightens swiftly and details fade. At Full Moon our line of sight parallels the blazing light from the Sun and shadows disappear. All detail is washed out completely in the noontime glare. But don't put your scope away! Full Moon is the best time to examine the intricate systems of light-colored rays that stretch away from Copernicus in a huge, webbed net that drapes across hill and plain alike.

Now the force of the impact that created Copernicus and pulverized millions of tons of rock is very apparent. The ray system is a titanic splash pattern, and the rays radiate outward in all directions for many hundreds of miles. And although they do not dominate the view as do those from Tycho in the southern highlands, their pattern is beautiful to look at for its own sake.

An unusual feature in the ray system is the lovely "oval rays." Although most lunar rays run arrow-straight, for some unknown reason a few Copernican rays fell to the ground in two looped patterns, one nested inside the other. Located two diameters southeast of the crater, the interior of the oval rays contains the darkest lava plain in Copernicus' immediate vicinity.

The Long Shadows of Afternoon

During the evenings that follow Full Moon the sunset terminator makes its entrance onto the lunar disk in the east. As the terminator marches slowly across the eastern hemisphere, the lowering Sun begins to paint Copernicus' features with shadows again. The afternoon is not simply a replay of the lunar morning: the Sun now shows new aspects of the features you have been viewing. As sunlight slants from the west, the eastern ramparts appear more rugged and the shadows on the inside of the western wall deepen and merge.

In the wee hours of a terrestrial night just before Last Quarter — about twenty-one days after New Moon — scan across the terrain lying to the northwest of the crater. There you'll see two chains of about twenty craterlets each, lined up like pearls on a string. These crater chains are secondary impacts, created by jets of rocks flung out of the crater in the impact explosion.

As the Sun sinks toward the lunar horizon, bringing the day at Copernicus to a close, terrestrial dawn will be brightening. Lunar shadows will become tinged with blue and the sunlit rocks will look yellow.

It is fascinating to observe the shadow of the western rim as it glides across the crater floor. The shadow's ragged edge proclaims the rough and jumbled nature of the crater's lip. The western rim, we recall, is the highest; its slow progression steadily erases from sight the terraces and peaks on the floor.

By the twenty-third day after New Moon, night is about to fall on Copernicus. The eastern outer walls reveal craterlets, hummocks, and ridges briefly before the Sun sets, while the western ramparts still glow brightly in the late afternoon Sun. Once again we see the terminator slide across Copernicus and highlight the crater's distinct hexagonal shape. Inside the rim, pools of shadow grow to fill the crater. The rim peaks flare one last time and then they, too, are gone. □

MOON VIEWING

While the ideal Moon telescope is a refractor in the 4- to 6-inch range or a reflector in the 8- to 12-inch class, even a lowly 60mm refractor can show you a lot, provided you understand what you are seeing.

At the other extreme, many of today's "light buckets" — big Newtonians optimized for faint deep-sky objects — capture too much light when turned on the Moon. These scopes work better with an over-the-aperture cardboard mask containing an offset hole, 4 to 6 inches in diameter. (For whatever size scope you have, however, an equatorial mounting is a real plus because it lets you scan the Moon at high power in comfort.)

A night of Moon-watching starts with setting your telescope outside to cool while you critically examine the sky conditions. The best nights for lunar observing are not necessarily the darkest. What counts most is *image steadiness*, and the nights with the most tranquil seeing are often quite hazy. If you look up and notice that the brighter stars are not twinkling at all, it may be a really great night for viewing the Moon — even if you have trouble spotting 4th-magnitude stars. (On the other hand, if Vega or Sirius is flashing like a diamond on black velvet, you are in for a real disappointment.) But whatever the case, don't give up until the Moon is about to set, because seeing can change during the night.

Lunar viewing is high-power viewing, much of it done at magnifications thirty to sixty times your aperture in inches. For example, on an 8-inch f/10 Schmidt-Cassegrain, 150x lets you study the area around Copernicus, but only the largest scale features are apparent. The bulk of your observing would use 250x to 300x and you would make occasional forays up to 500x whenever the seeing became exceptionally steady.

Michael T. Kitt is a member of the Association of Lunar and Planetary Observers. His most recent ASTRONOMY article about the Moon, "Looking for Lunar Fractures," appeared in the February 1988 issue.

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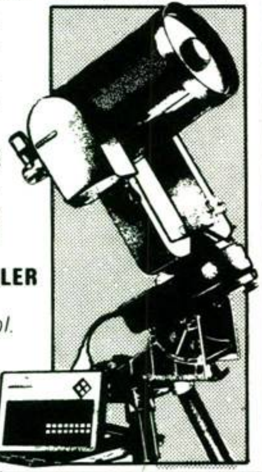

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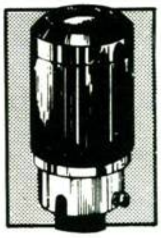

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Southern Clusters of All Ages

The color and density of a cluster can tell you a lot about the age of the cluster's stars.

by Gregg D. Thompson

Scattered along the Milky Way, groups of stars called open clusters offer you a chance to peer into the history of the universe. These clusters contain a record of their past: astronomers study the light from stars in open clusters to discover everything from the ages to the distances and sizes of clusters. Many of the finest open clusters lie in the southern sky, invisible to Northern Hemisphere observers. Nine of the southern sky's best clusters are intrinsically brilliant objects visible to the naked eye.

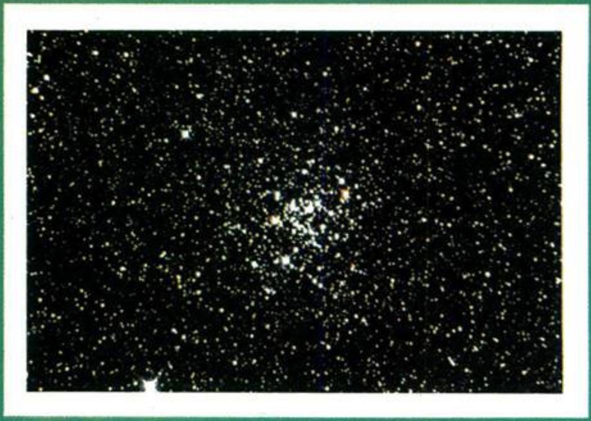
Of all the bits of knowledge astronomers collect about open clusters, age is the most revealing. Because stars change as they mature, the brightnesses and colors of open cluster stars provide clues to the cluster's age. In general, the bluer the stars, the younger the cluster; the redder the stars, the older the cluster. This in turn lets astronomers uncover the cluster's past and look into its future.

Open clusters are typically little groups of a few dozen to a few hundred stars that form from gas clouds. Open clusters live their lives in the Milky Way's disk, slowly rotating about the galactic center. They are perishable: few open clusters last longer than one or two rotations around the center of the Galaxy. Gravitational tugs from passing clouds of dust and other objects eventually tear away the stars of most open clusters and disperse the stars throughout the Galaxy's disk.

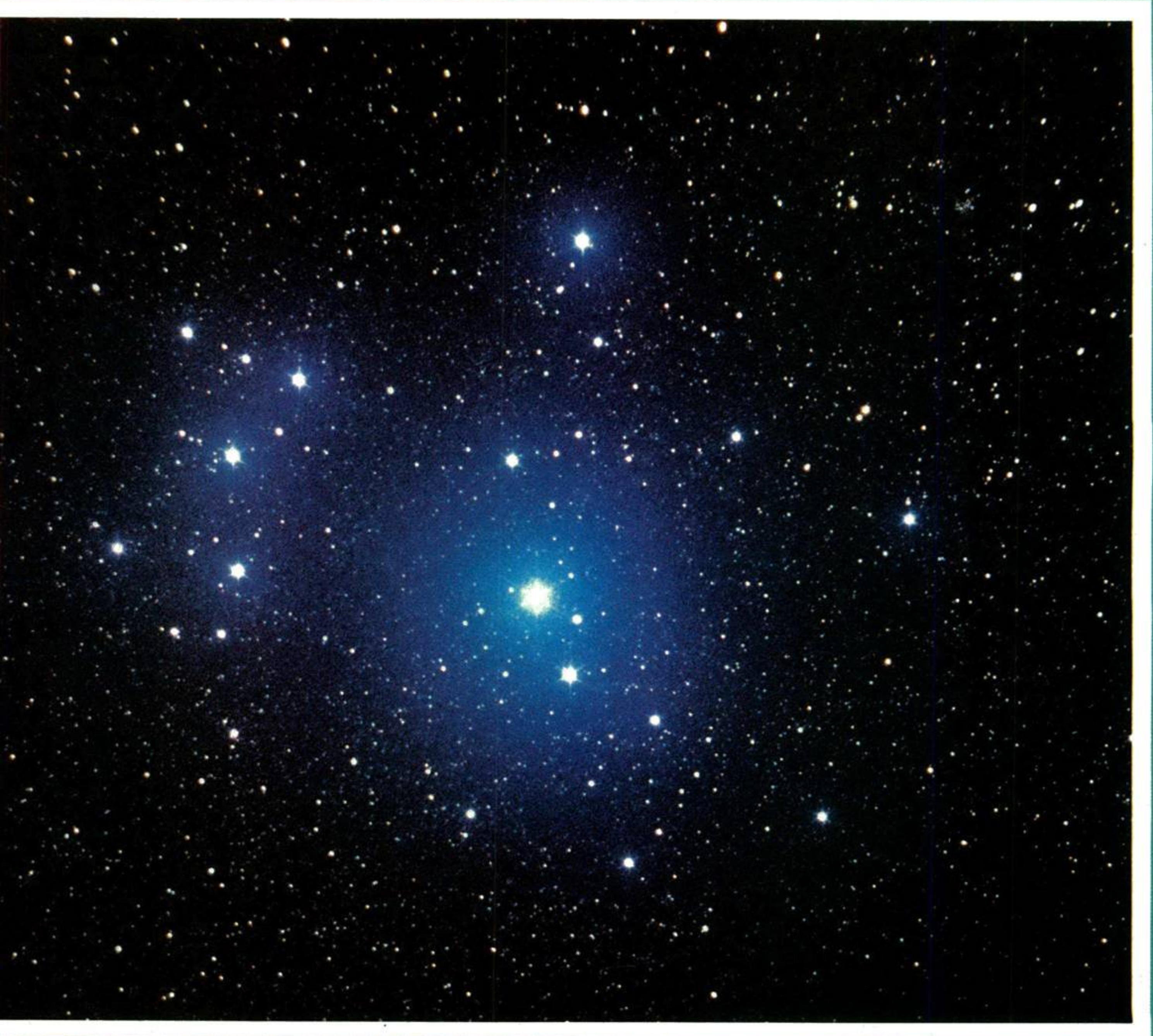
The southern sky's brightest clusters vary greatly in age and characteristics. The youngest is NGC 4755, a group of stars in Crux, one third the size of the Moon. Known as the Jewel Box because of its sparkling blue-white and orange stars, NGC 4755 formed about 7

NGC 4755 Crux

NGC 3293 Carina



NGC 3766 Centaurus



IC 2602 Carina

IC 2391 Vela

NGC 6067 Norma

NGC 2516 Carina

million years ago — very recently in astronomical terms. The cluster is dominated by young, extremely hot, blue and white stars. These stars are intrinsically bright and make the Jewel Box faintly visible to the naked eye even though the cluster lies at the great distance of 7,500 light-years.

The Milky Way clouds in Carina hold another young cluster. A naked-eye object 8,500 light-years away, NGC 3293 is similar in age and appearance to the Jewel Box. This cluster lies in a busy area of the Galaxy within the so-called Carina OB1 and Nebular complex, a region of dust, gas, and young stars. If you aim a pair of binoculars at NGC 3293, you'll see that NGC 3293 is a rich cluster. And if you aim a medium-sized telescope at NGC 3293, you'll see over two hundred stars within the cluster's boundary.

Lying near the famous Eta Carinae Nebula, NGC 3766 is intrinsically one of the most luminous clusters in the Milky Way. It is also young, estimated to be about 20 million years old. In our sky NGC 3766 is a faint naked-eye object because it lies at the great distance of 6,200 light-years. Many of the brightest stars in NGC 3766 are blue and white, but there are also yellowish stars and three red stars. The yellow and red stars are relatively cool stars visible because they are extremely brilliant.

Astronomers estimate that the cluster IC 2602 in Carina is between 4 million and 20 million years old. Sometimes called the "Southern Pleiades," this cluster is bright and splashy even when viewed with the naked eye. IC 2602 glows with the light of a 2nd-magnitude star and covers an area larger than that of the Full Moon. The most brilliant stars in IC 2602 are supergiant stars — extremely large and luminous objects — that shine blue and blue-white.

Young groups of stars also lie in Vela and Norma. IC 2391 in Vela (30 million years old) shines at magnitude 2.5 and has a diameter larger than that of the Moon. It contains thirty stars. NGC 6067 is a rich cluster occupying the central position in the Norma star cloud. Although NGC 6067 lies 6,800 light-years away, it is a naked-eye object in our sky. In binoculars, look for nine orange-colored giant stars among the mostly blue and white crowd. Although some colorful stars are visible in this cluster,

NGC 3114 Carina

NGC 3532 Carina

NGC 6067 is still relatively young at 78 million years and is dominated by blue and white stars.

Carina's NGC 2516 and NGC 3114 are middle-aged open clusters that have a richer variety of star types than younger clusters have. NGC 2516, a group shining at magnitude 3.8 and measuring 30′ across, is one of the most colorful clusters in the southern sky. This group is about 110 million years old and contains three red stars and a smattering of yellow and orange stars. As old as NGC 2516, NGC 3114 is a rich cluster that lies about twice as far away as NGC 2516. Compare the two in binoculars and you'll see a great difference in appearance. Although the two contain similar types of stars, the difference in distance makes NGC 3114 appear much smaller and its stars less colorful.

Also located in Carina, NGC 3532 is much older than the other bright clusters in the southern sky. At 200 million years old, this group of stars has a substantial collection of highly evolved stars with abundances of heavy metals. Observe this group with binoculars and you'll see a preponderance of yellow and orange stars but not many blue stars. The stars in this group are much closer to the ends of their lives than those in clusters like the Jewel Box.

NGC 3532 is big and split into two distinct stellar lanes that together contain one hundred stars brighter than 14th magnitude. NGC 3532 has almost completed one revolution about the center of the Galaxy. In another 300 million or so years this cluster will have orbited the Galaxy twice, and by then the cluster may be torn apart and its stars distributed throughout the Galaxy's disk.

Young or old, open star clusters reveal a piece of the universe's past. Looking at them allows us to see a "still frame" from the great movie that is the changing universe. If you live in the Southern Hemisphere, compare these bright clusters and see what they tell you. If you are a northerner, a trip down south will show you some of the most magnificent objects in the heavens. ☐

Gregg D. Thompson is an active deep-sky observer who owns Springwood Observatory in Queensland, Australia. He is co-author of a book of supernova search charts to be published by Cambridge University Press this fall.

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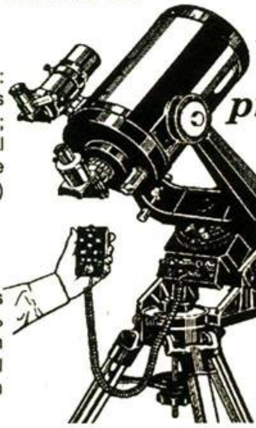

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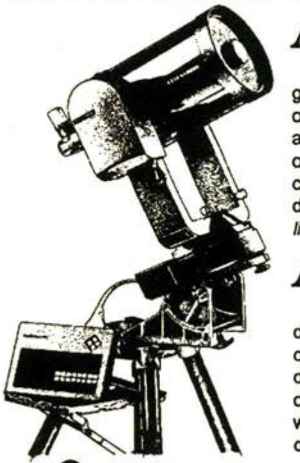

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Take a justly famous and optically magnificent Celestron Powerstar II – add some extra features, like a T-adapter, tele-extender, dew shield, and Sky Maps – and you have the new Powerstar *III*. You get all these other features, too: the latest Starbright optical coatings; 8 x 50mm illuminated polar axis finder; 26mm Plossl (77x) and 7mm ortho (286x) eyepieces; quartz-controlled electronic drive with power adapters for AC and penlight battery operation; drive corrector/hand control with built-in map light and controls for optional electric focuser; equatorial wedge; adjustable height tripod; heavy duty Samsonite-type foam-lined carrying case; lifetime warranty, and more! *$3122 list*, **for only $1599!** (An optional $\$160^{00}$ declination motor that converts the drive into a dual axis drive corrector for astrophotography is only $\$112^{50}$.) Quantities are *very* limited on this special production run telescope, so don't miss out.

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Celestron has updated their best-selling C90 spotting scopes – and we've got them all in stock! These are not the discontinued, inverted finder image, uncoated models that some dealers offer. These are the very latest models – some with *multi-coated* optics for visibly higher light transmission and increased contrast, some with rubber armor for hard use in the field. Each has an 8x finder with a very wide 7° field and upright/correctly-oriented images, plus a 45° prism diagonal that provides both upright and correctly oriented images *and* a comfortable viewing angle. Each comes with a 33x eyepiece and a unique Samsonite-type carrying case fitted to hold your camera and photo accessories, as well as the spotting scope! They're super 3.5" f/11 spotting Maksutov scopes at sensible prices that save you over 40%!

C90, erect image finder, 45° erect image diagonal, 33x eyepiece, case, *$650 list*	$\$379^{00}$
C90, as above, but with multi-coated optics, *$710 list*	$\$409^{00}$
C90, same as basic C90 above, but with rubber armor, *$730 list*	$\$419^{00}$
C90, as above, but with rubber armor and multi-coated optics, *$790 list*	$\$459^{00}$

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EQUIPMENT ENHANCEMENTS

SOUP UP YOUR SMALL SCOPE

Rev up the performance of your telescope with accessories like high-quality eyepieces and a good finder scope.

by Rick Shaffer

Do you have a "thrown-away" telescope in your house?

You know, the old 60mm refractor that's been lurking in the closet for the past year — or the long-neglected 4¼-inch reflector gathering dust in the attic.

Or perhaps it's that once-proud telescope you spotted last weekend at a yard sale, now propped up in a corner. Who could say no to the $15 they wanted for it?

In these cases you have an unloved instrument on your hands, a telescope owned by someone — perhaps it was *you* — who long ago threw it away, mentally at least, if not physically.

Let's look carefully at this instrument for a moment. Telescopes don't come cheap and few people part with one unless there's a good reason. Usually telescopes wind up in attics or at garage sales when their owners become fed up with tripods that shake so much nothing can be seen clearly, with blurry views that are acceptably sharp only with the lowest-power eyepiece, or with finder scopes so hopelessly dim they barely show Betelgeuse.

Does your tale of woe sound familiar? Yet as discouraging as these problems are, each of them nonetheless has a simple remedy. Buying a new, high-quality eyepiece or aligning the optics often works wonders. So will a new finder scope. And so on. You will find that upgrading your telescope is a step-by-step process. It does not commit you to any big purchases and, by going at the project incrementally, you can spread out whatever cost there is over several months. And when you have finished, you'll take great pride in knowing that you coaxed every last ounce of performance from that old junker.

The all-important first step, however, is to eliminate every correctable source of shakiness in the mounting. (See "The Mount of Gibraltar" in the August 1988 issue.) Without doing that, the rest of the improvements are largely wasted. Only when your telescope has a stable support should you turn your attention to bettering its ability to find celestial objects and improving the view through the eyepiece.

Not much of a handyman? Relax, you don't have to be. Most of the changes involve substituting one ready-made part for another. And if you still feel uncertain, see if there's an astronomy club in your area. (Ask the public library or a local high school science teacher.) Almost every astronomy club has at least one member with some experience building telescopes or renovating old ones who can advise you.

Find a Better Finder

Most small telescopes feature very small, very poor finder scopes. It's not that the telescope designers deliberately set out to make lousy finders. Rather, they were given the task of designing a telescope that could be mass-produced for a price a first-time telescope buyer would pay while ensuring a reasonable profit for the company. Nevertheless, the fact remains that most of these finder scopes are real losers. Let's examine the problem in detail.

Many small import scopes, especially the lowest-priced models, carry a finder made with a single-element objective (main) lens typically 20mm to 25mm in diameter. Single-element lenses are not color-corrected. This means that as they form an image, they split the light into its component colors, bringing each color to a slightly different focus. As a result the image of a bright star or planet, for instance, is surrounded with a colorful halo that distracts your eye and obliterates detail. In addition, cheap, single-element lenses have a second problem called spherical aberration, which means rays of light passing through the edges of the lens come to focus in front of those that go through the center. The result, again, is a mushy image.

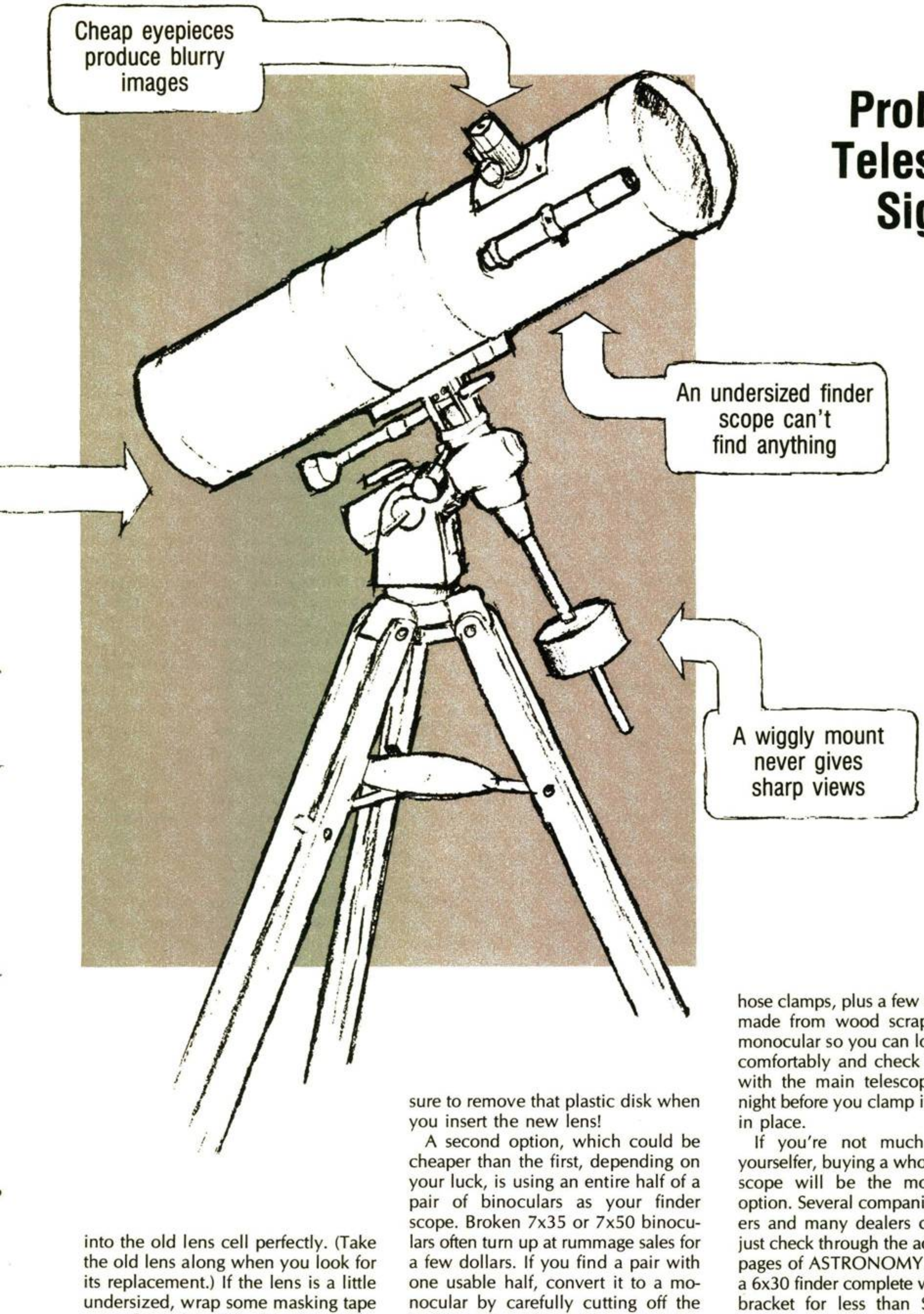
Bad collimation guarantees fuzzy images

To reduce these defects, the manufacturer places a disk of opaque plastic just behind the lens. A hole in the center of the disk limits the real aperture of the finder to approximately 5mm, which eliminates the edge rays and removes most of the excess color. But 5mm is smaller than the aperture of most people's dark-adapted eyes. And because these finders typically magnify five times yet have no more aperture than your naked eye, they actually make the images of extended objects look about twenty-five times dimmer than a naked-eye view! This light loss doesn't matter with the Moon or the brighter planets, but it's disastrous when you want to find a faint object.

There are three remedies to this problem. The cheapest option is replacing the single-element objective lens on your finder with an achromatic (color-corrected) objective from a defunct pair of binoculars. The market is currently flooded with medium-quality compact binoculars of 21mm to 25mm aperture. One of these is just waiting to be cannibalized for your finder-upgrade project — check out the local camera repair shops and visit every garage sale in your area.

Attaching the new lens to the old finder tube can be easy or difficult. If the sizes match, the new lens will slip

Problem Telescope Signs


Cheap eyepieces produce blurry images
An undersized finder scope can't find anything
A wiggly mount never gives sharp views

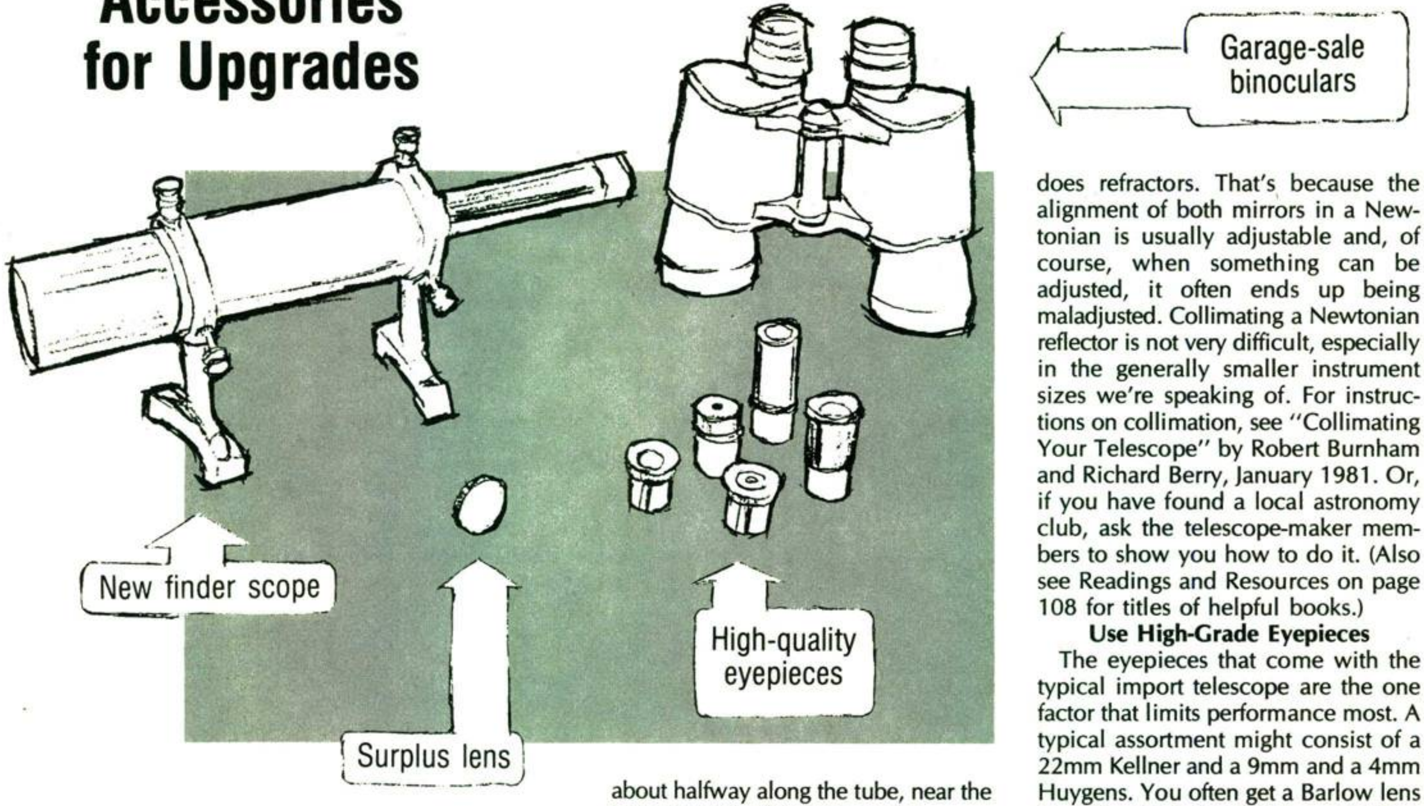
into the old lens cell perfectly. (Take the old lens along when you look for its replacement.) If the lens is a little undersized, wrap some masking tape around its edge. If the lens is too big, try transferring the binocular lens cell to the finder tube. If that doesn't work, investigate what the plumbing department of a home center or hardware store can provide in the way of plastic pipe and fittings. Whatever solution you choose, however, be sure to remove that plastic disk when you insert the new lens!

A second option, which could be cheaper than the first, depending on your luck, is using an entire half of a pair of binoculars as your finder scope. Broken 7x35 or 7x50 binoculars often turn up at rummage sales for a few dollars. If you find a pair with one usable half, convert it to a monocular by carefully cutting off the broken side with a hacksaw.

Attaching the monocular to the tube, however, will probably be more difficult than retrofitting an objective lens because the monocular has an irregular shape. Try using hard rubber from the plumbing department of your hardware store and two automobile hose clamps, plus a few spacer blocks made from wood scrap. Mount the monocular so you can look through it comfortably and check its alignment with the main telescope's optics at night before you clamp it permanently in place.

If you're not much of a do-it-yourselfer, buying a whole new finder scope will be the most appealing option. Several companies make finders and many dealers carry them — just check through the ads in the back pages of ASTRONOMY. You can get a 6x30 finder complete with mounting bracket for less than $50. A 6x30 (which means that the finder magnifies six times and that its objective lens is 30mm in diameter) is the minimum size acceptable; if you can afford to spend more, go for an 8x50. Although this size is larger and heavier and costs close to $100, many telescope owners prefer the 8x50 because its

Accessories for Upgrades



light grasp is almost three times that of a 6x30. This lets it reach deep enough to find a lot of faint celestial objects that a 6x30 misses.

If you want a new finder but your budget doesn't stretch quite far enough, try placing a want ad in the newsletter of a local astronomy club. Sometimes even this isn't necessary. At the monthly meetings of my club we have a short period near the end during which anyone may stand up and ask questions or "publish" a verbal want ad. Also try to attend one of the many astronomy swap meets that seem to be springing up everywhere.

Attaching a new finder will probably mean drilling holes in the telescope tube. First, however, see if the new finder will fit in the old brackets with enough room to adjust the aim. If it doesn't fit, you will have to install new brackets. But before you drill any holes in the tube, check the telescope's balance with the new (and probably heavier) finder and brackets on board. Move the finder assembly back and forth on the tube, holding it temporarily with duct tape until you find the place where you can look through the finder conveniently and where it doesn't upset the telescope's balance. If your telescope has a rotating or sliding cradle, move the tube back and forth to compensate for differences in weight. But if the tube is bolted permanently to the mounting, figure on placing the finder assembly about halfway along the tube, near the scope's original balance point.

Line Up the Optics

Many people are surprised to learn that most small import telescopes feature very high quality objective lenses or primary mirrors. Why, then, is the performance of these telescopes so disappointing? Aside from the shaky mounting problem, the main causes are poor alignment of the telescope's optics and the low-quality eyepieces originally supplied with the scope. If you correct both of these problems, the odds are very high that you will be astonished by the improvement in your telescope's performance.

The optical axis of any telescope is an imaginary line that passes through the center of all the lenses or mirrors (the objective as well as the eyepiece) and is perpendicular to the lenses or mirrors. The process of adjusting the various elements so the optical axis of each coincides with all the others is called *collimation*.

A refractor will be collimated properly at the factory and with normal use should hold that alignment forever. The only problem that sometimes occurs is that the objective lens elements become cocked in the cell because of gross mishandling or that one or more of the small tabs of metal foil that sometimes separate the two elements work loose and get lost. If you suspect either problem, consult your local telescope-making guru or a camera repair shop.

Bad collimation affects Newtonian reflectors much more often than it does refractors. That's because the alignment of both mirrors in a Newtonian is usually adjustable and, of course, when something can be adjusted, it often ends up being maladjusted. Collimating a Newtonian reflector is not very difficult, especially in the generally smaller instrument sizes we're speaking of. For instructions on collimation, see "Collimating Your Telescope" by Robert Burnham and Richard Berry, January 1981. Or, if you have found a local astronomy club, ask the telescope-maker members to show you how to do it. (Also see Readings and Resources on page 108 for titles of helpful books.)

Use High-Grade Eyepieces

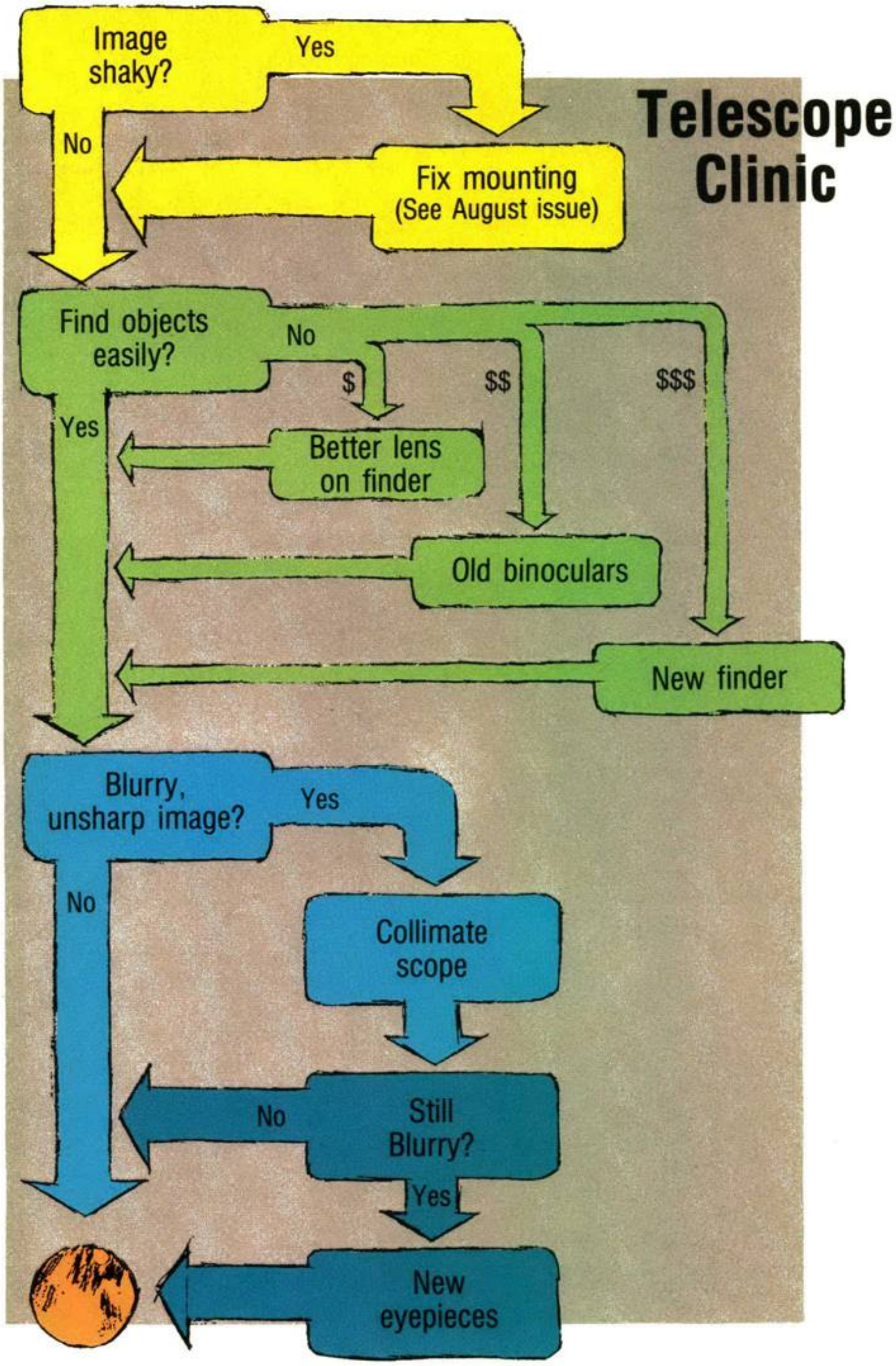
The eyepieces that come with the typical import telescope are the one factor that limits performance most. A typical assortment might consist of a 22mm Kellner and a 9mm and a 4mm Huygens. You often get a Barlow lens as well, which doubles the magnification of each eyepiece. A Kellner eyepiece features three lens elements, while the Huygens design has only two. In general the fewer lenses an eyepiece has, the narrower the field of good definition. However, the problem with the eyepieces that come with most cheap import telescopes is not so much bad design but poor manufacture.

The right way to make a lens — the expensive way — is grinding the lens to shape on a machine and then polishing its surfaces until all of the pits caused by grinding have been removed. The lens is then tested and its final shape corrected to just the right figure. Finally, the edge is ground smooth and round so the lens can be accurately held in its cell.

The *cheap* way to make a lens, especially a small one, is to carve a mold, pour molten glass into it, press another mold on top, let the glass cool a bit, and — *poink!* — out pops a lens. You then polish the rough-finished lens at high speed with a cloth wheel and put it into the eyepiece cell.

I've disassembled the eyepieces of many small imported telescopes and have found that the lenses in most are molded. They are *not* precision lenses and the eyepieces made from them will give barely satisfactory images at best. To get good performance, therefore, you should replace the eyepieces with high-quality ones.

There are several ways to get better eyepieces for your telescope. The



easiest is simply to buy a replacement set of Kellners or orthoscopics from one of several firms who sell them. The orthoscopic is a more advanced design than the Kellner and has four lens elements; the Kellner, you recall, has three. The choice you make will likely be dictated by price. But in a way it won't matter too much which you choose, because the replacement *eyepieces* of either design that I have seen are of far higher quality than the eyepieces most small imports are supplied with.

Prices? On occasion you can find these eyepieces going for as little as $20 each, but $35 to $40 is more common. A good set of eyepieces to have would be 25mm, 18mm, 12.5mm, 9mm, and 6mm.

If your budget allows you to buy only one or two eyepieces at a time, get the low-power 25mm and 12.5mm ones first. These yield the two most useful magnifications. Then buy a 9mm, an 18mm, and a 6mm in that order. The 9mm increases the available power and the other two complete the basic range. You should also consider getting a good-quality Barlow lens to replace the (probably) substandard one that came with the telescope.

Many owners of large Newtonian reflectors upgraded their eyepieces in recent years when new designs came on the market. This means a large number of older Kellner and orthoscopic eyepieces are available for as little as $10 to $15 each through astronomy club want ads, swap meets, and the Reader Exchange section of ASTRONOMY.

However, as always, there's a catch. Most imported telescopes accept only eyepieces with a 0.965-inch-diameter (24.5mm) barrel, while most surplus eyepieces available in North America are 1¼ inches in diameter. What to do? Well, here's where the various dealers in accessories come to the rescue once again. Several of them (check their ads) sell an adaptor for about $20 that mates a 1¼-inch-diameter eyepiece to the 0.965-inch focuser supplied on most imported scopes. (This adaptor will, however, slightly limit the field of view with a low-power 1¼-inch eyepiece. Also, your focuser must have an extra inch of travel toward the objective to accommodate the adaptor's additional length.)

A more ambitious solution is to install a 1¼-inch focuser on your telescope. Bought new, these don't come cheap, though you may be able to scavenge a used one that is the right size for your telescope. But installing it will probably involve more surgery on the tube than putting on a new finder scope, and if you're not an experienced telescope maker, it would be wise to consult someone who is before you embark on such a modification.

By now that "discard" telescope ought to be looking and performing its best. Far from throwing good money after bad, you have instead restored to the telescope those parts and accessories it needed to be a truly good instrument — but that it was denied by the economics of the mass marketplace.

On nights of excellent seeing, your newly tuned-up telescope will show you the irregularities in the belts of Jupiter. And look, there's the Great Red Spot! That 2-arcsecond double star it couldn't resolve before now splits beautifully. Tiny craterlets and rilles on the Moon snap into focus. The brighter deep-sky objects don't look quite so deep in the sky any more.

In short, you now have a real telescope — enjoy! ☐

Rick Shaffer is an engineering manager on the Magellan *project at the Jet Propulsion Laboratory in Pasadena, California. He also writes the Through the Eyepiece column in ASTRONOMY. His most recent article on small telescopes was "The Mount of Gibralter" in the August 1988 issue.*

Do-It-Yourself Color Processing

Not only can you see your astrophotos fast, but you can compensate for mistakes in exposure time when you process your own color slides.

by Rick Dilsizian

Imagine shooting a roll of color astrophotos tonight — and seeing the results tomorrow. Or underexposing a roll of slides and fixing the problem. Or never again having slides accidentally chopped in mid-frame by your local film processor.

It is not a dream. Every one of these benefits is within the reach of astrophotographers who process their own film. Best of all, you don't need to be some kind of chemistry wizard. Processing color slides is easy — it is no more difficult than processing black-and-white film — and a lot of fun.

How does a beginning astrophotographer benefit from processing his own film? One major advantage is seeing the results of your efforts right away. This helps you check your work and evaluate the progress you're making. At-home film processing also lets you compensate for some goof-ups. And, finally, film processing is relatively inexpensive and not very time consuming.

Advanced astrophotographers can reap even more benefits. First, the processing is controlled by you, not by the U.S. Mail or the processor you send the film to. Second, you can exercise greater care in handling. (How many times have your slides come back scratched from a film lab?) And you can see the finished slides right away and thereby avoid any major anxiety attacks. "Did I track all right?," "Were my shots in focus?," and "Was my scope aligned precisely on the pole?" are questions you will quickly know the answer to — for better or for worse!

Processing Color Slides

The *simplest* way to process color slide film, and one that gives consistent, high-quality results, is the E-6 process. The E-6 process works on most color slide films — Ektachrome, Agfachrome, and Fujichrome. (Kodachrome demands more sophisticated processing, so you have to send it to a large laboratory.) But E-6 is definitely for do-it-yourselfers. Any astrophotographer can develop film with the E-6 process using a self-contained, prepackaged set of chemicals. I recommend the Kodak Hobby Pack Color Slide Kit. It's easy to use, cheap, clean, and fun.

The procedure begins with an exposed roll of color slide film. Photographic film consists of an emulsion of silver-halide crystals (either silver chloride, silver bromide, or silver iodide) in suspension with gelatin. Color film contains three separate layers, one for each of the primary colors: blue, green, and red. Each layer contains special sensitizing dyes that act as filters for the silver halide in that layer's emulsion.

During an exposure, light passes through the blue layer first, because that layer is on top. This layer records the blue component of light from the astronomical object. But because the silver halide in the other layers is also sensitive to blue light, filmmakers place a screening layer immediately under the blue layer to filter out all remaining blue light.

The green layer comes next and contains special dyes that make its layer's silver-halide crystals sensitive to green light only. The remaining incoming light — now stripped of its blue and green components — passes to the red layer and is recorded.

Immediately below these emulsion layers is a transparent support layer. Think of it as the film's foundation, upon which the emulsions above are deposited. The bottom layer improves image definition by absorbing light that has passed through all of the emulsion layers and thus prevents it from reflecting back into those layers.

When a photographic emulsion is exposed to light, a change takes place in the emulsion's silver-halide crystals. This change produces a "latent image" composed of altered silver-halide crystals.

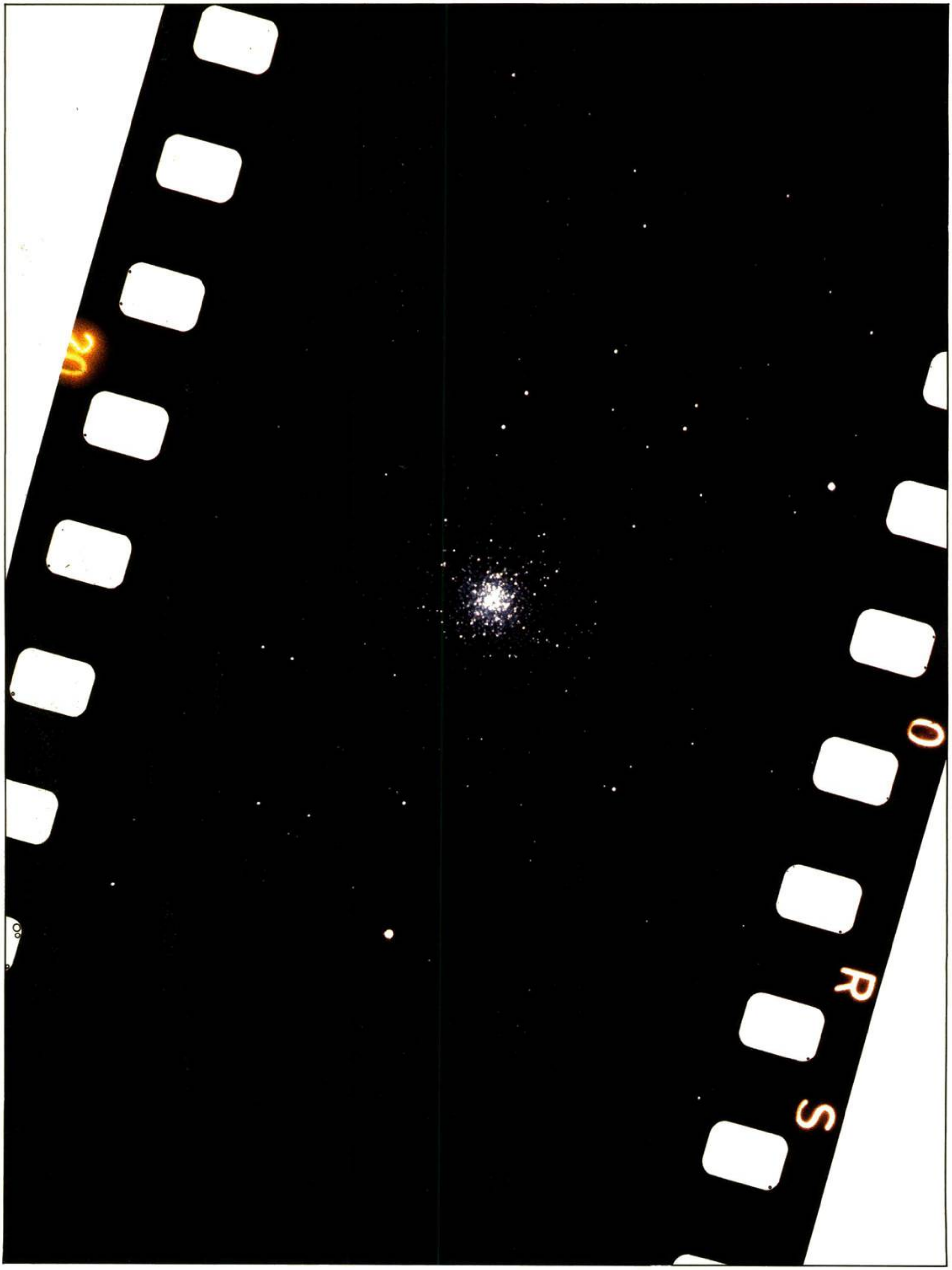
The latent image becomes visible in the first step of the E-6 process. The color slide film is immersed in a black-and-white developer solution that changes the exposed crystals of silver halide to metallic silver and leaves the unexposed crystals unchanged. The amount of silver created from the silver halide in each of the three color layers is proportional to the exposure each received. This in turn depends on how much light of each color there is in the object photographed. The result of this first development is a sandwich of three black-and-white images.

The Reversal Stage

In the next step the unexposed and undeveloped silver halide in the film must be altered so the positive image left by first development can be processed by the color developer. This step is known as the reversal stage. Reversal can be accomplished either chemically or by exposing the crystals to light. At the end of this step the film has a latent image formed during the reversal stage in some areas and metallic silver created during the first development stage in the other areas.

The second development stage attacks the latent image produced in the reversal stage. The developer creates metallic silver from the exposed silver-halide crystals and in the process becomes oxidized. This oxidization causes the second developer to react with color chemicals in each emulsion layer to produce color dyes where the new metallic silver has formed. In each layer of the film the dye produced is the complement of that layer's color — yellow in the blue layer, magenta in the green layer, and cyan in the red layer.

Bleaching and fixing come next. Bleaching converts the metallic silver in the film back to silver halide and leaves behind an image made of pure color dyes. Fixing then dissolves the



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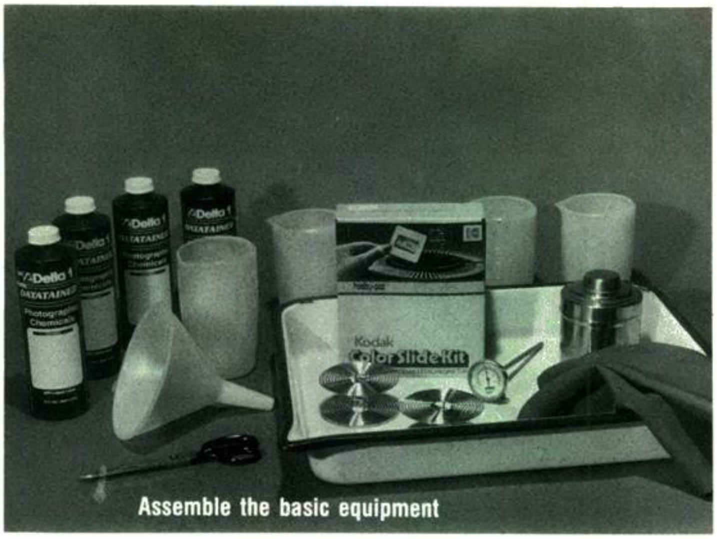
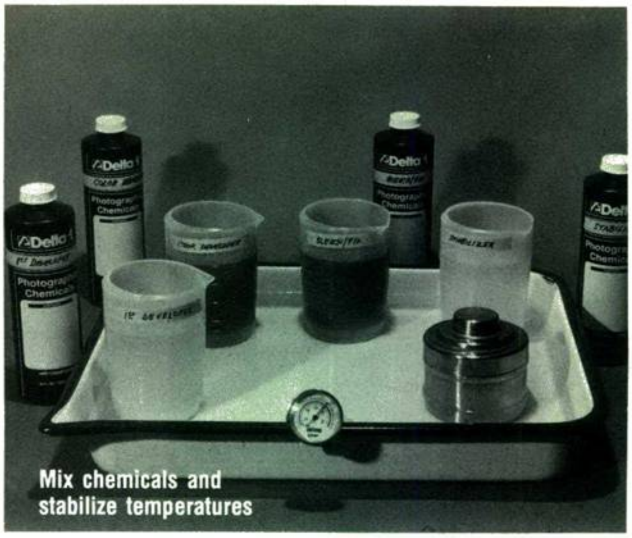


Assemble the basic equipment



Mix chemicals and stabilize temperatures

STEP-BY-STEP COLOR PROCESSING

1 Mix the chemicals in four beakers or graduates and choose a convenient processing temperature.

2 Immerse the beakers in a tray filled with water slightly hotter than your chosen temperature; monitor the solutions' temperature.

3 Once the solutions reach the desired temperature, remove the processing reel from the processing tank and pour the first developer into the tank.

4 Turn out the lights, pry open the film canister, and wind the film onto the processing reel.

5 Cut the trailing edge of the film from the film spool.

6 Immerse the reel into the first developer, put on the tank lid, and turn on the lights. Start the timer and begin agitation, and then agitate the tank for 5 seconds every 30 seconds.

7 When the first development time is up, pour the first developer out of the tank through the light-tight trap into its storage bottle.

8 Reset the timer to zero.

9 Pour water into the tank through the light-tight trap, vigorously agitate the tank for 45 seconds, and then drain it. Repeat four times.

10 Remove the tank lid and reset the timer to zero.

11 Pour the color developer into the tank and start the timer. Agitate the tank for 5 seconds every 30 seconds.

12 When the color development time is up, pour the color developer into its storage bottle.

13 Reset the timer to zero.

14 Fill the tank with water, agitate for 30 seconds, and then drain it. Repeat four times.

15 Reset the timer to zero.

16 Pour the bleach/fix into the tank, start the timer, and agitate the tank 5 seconds every 30 seconds.

17 After 10 minutes pour the bleach/fix into its storage bottle.

18 Reset the timer to zero.

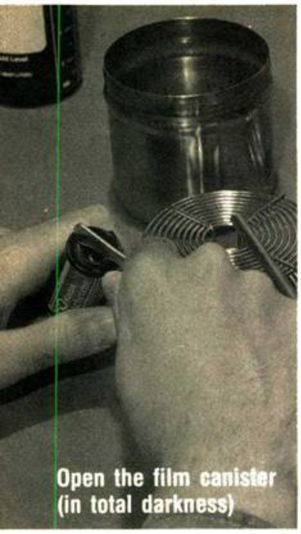
19 Fill the tank with water, start the timer, agitate the tank briefly, and drain it. Repeat six times in 4 minutes. (Or wash in running water for at least 4 minutes.)

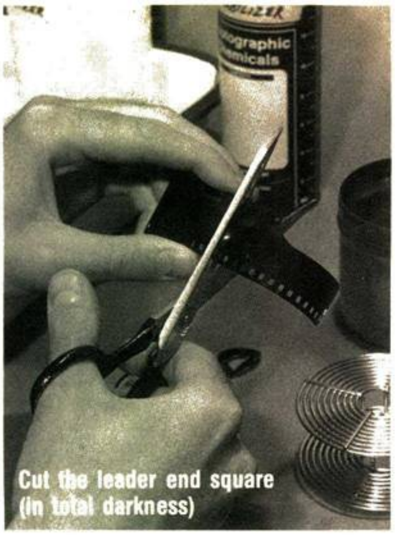
20 Reset the timer to zero.

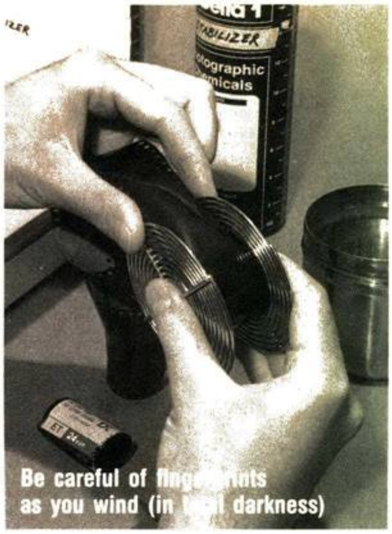
21 Pour the stabilizer into the tank, start the timer, and agitate for the first 5 seconds only.

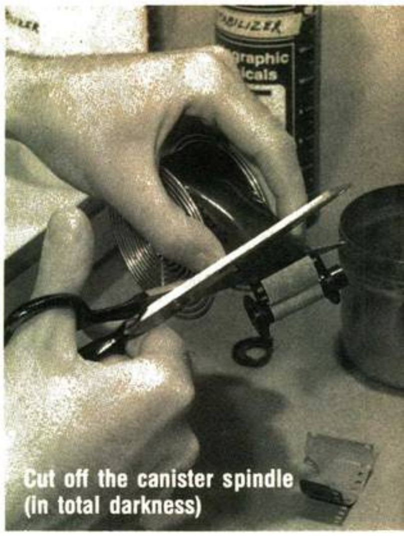
22 After 1 minute pour the stabilizer into its storage bottle.

23 Hang the film to dry.


Open the film canister (in total darkness)


Cut the leader end square (in total darkness)


Be careful of fingerprints as you wind (in total darkness)


Cut off the canister spindle (in total darkness)

silver halide completely and a final washing of the film removes them. At this point you have a positive image, but the color dyes lack longevity.

Stabilization is the final step. The stabilizer solution prevents strong light and heat from oxidizing the dye layers in the film and thus insures the permanence of the dye layers.

Getting Prepared

Despite the seemingly complicated chemical nature of slide developing, doing it is quite simple. All of the chemicals you need — the developers, bleach/fix and stabilizer — are in the Kodak Hobby Pack. But there is additional equipment you'll need to get before you process film at home.

First, you will need a totally dark area for loading the film onto a proccessing reel. One possible location is a closet, especially at night, though check to see if it is light-tight by letting your eyes dark adapt and then making sure you still can't see anything. You will also need running water for proccessing; an old bathroom or even the kitchen sink works fine.

Next you'll need a bottle opener to remove the bottom of the film canister. You'll also need scissors to cut the ends of the film square for loading onto the developing reel. A daylight developing tank will let you process the film in total darkness while the room lights stay on. These tanks are available at full-service photo stores and some department stores.

Once the slides are processed, they have to dry in a dust-free environment. And in that dust-free area you'll want a hook to hang the film on to dry and a paper or plastic clip to act as a weight on the bottom of the film so the film doesn't curl. Once the slides are dry, you'll need some polyethylene envelopes or slide mounts for storing them. Poly envelopes are soft and won't scratch your slides the way regular envelopes might.

You'll need four 500-milliliter storage bottles, preferably made of brown polyethylene, for storing the chemical solutions. To mix the solutions you'll need four containers — beakers or graduates — large enough to hold 500 milliliters. Never mix more than one solution in a beaker, because any chemical contamination can adversely affect the developing process. To pour the chemicals from the beakers into the storage bottles, you'll need a set of funnels to keep the chemicals from splattering.

Remember that the chemicals used in film processing are potentially dangerous. Wear rubber gloves and goggles when you mix the chemicals and when you process the film — the chemicals can be absorbed readily through the skin.

Finally, you'll need an immersion heater — the kind used to heat a cup of coffee — to raise the chemicals to the desired temperature, a thermometer to make sure you reach the right temperature, and a large, deep tray — a plastic dishpan about 16 inches by 20 inches by 4 inches deep works well — in which you can place all four beakers to bring the chemicals up to the desired temperature.

A Color-Processing Checklist

The beauty of the Kodak kit is that the kit is easy to use. All of the chemicals are provided in liquid form, ready to pour and mix. The kit provides a "slide rule" type table so you can find a processing time and temperature combination for your particular needs. Though Kodak recommends a processing temperature between 96° and 110° F., the table gives processing times for temperatures down to 70° F. Remember that the higher the temperature during processing, the less time processing the film takes.

To develop a roll of exposed film, first get out the kit and the equipment mentioned earlier. Then mix the chemicals in the four beakers. You can then process the film using the following step-by-step procedure.

1. Determine the processing temperature you want by consulting the time/temperature table on page 8 of the kit manual or the quick-reference process guide.

2. Immerse all four beakers in the large tray and fill the tray with water at a slightly higher temperature than desired for processing. Monitor the temperature of the solutions as you run water into the tray. Make sure each solution is at the desired temperature. (Rinse the thermometer *thoroughly* before checking a new solution's temperature or you'll ruin the chemicals through contamination.)

A practical way to heat the water in the tray to the desired temperature is with an immersion heater. Hold the heater by its handle and stir it through the water, making sure it does not remain stationary for too long. Avoid touching the heating element during this step — it can burn you severely.

3. Once the solutions reach the desired temperature, take the processing reel out of the processing tank. Then pour the first developer from its beaker into the processing tank.

4. Probably the trickiest step of the entire procedure is loading the film onto the processing reel, because this must be done in the dark. First pry open the bottom of the film canister with the bottle opener. Once the film is out, cut the tapered leading edge so it is square to the sides of the film.

Metal wire developing reels load from the core outward. Insert one end of the film (cut square) into the reel's center spindle by crimping it gently. Then wind the film slowly, being careful not to kink it. Practice with a throwaway roll of film first — you will be hopelessly clumsy at first. You are ready when you can load the film faultlessly with your eyes closed.

5. Once the film is fully loaded onto the developing tank's reel, cut

Delta 1
BLEACH/FIX
Photographic Chemicals
Delta 1
STABILIZER
Photographic Chemicals
COLOR DEVELOPER
BLEACH/FIX
STABILIZER

Drop loaded reel into warmed tank (in total darkness)

Delta 1
Delta 1
BLEACH/FIX
Photographic Chemicals
STABILIZER
COLOR DEVELOPER

Pour developer into the tank

the trailing edge of the film from the original film spool with scissors.

6. Immerse the reel in the first developer, cap the top, and begin agitation. Make a note of the time you start the development, either by starting a timer or by writing the time on a piece of paper. Agitate the processing tank for 5 seconds every 30 seconds by gently shaking the tank to and fro. This insures that each section of film develops evenly and also releases trapped air bubbles that could ruin your slides.

7. The first development is done when you reach the desired processing time. At this point, pour the first developer from the tank — with the lid on — back into its storage bottle using a clean funnel.

8. Reset your timer or cross off the time on the paper.

9. Next pour water at the same temperature as the other solutions into the tank through the light-tight trap in the lid. Start the timer or write the time on a piece of paper. Agitate the filled tank for 45 seconds and then drain it, repeating the cycle four times.

10. Remove the cap from the top of the processing tank and reset the timer or cross out the time marked on the paper. Room light is safe for the film from this point on and the cap no longer needs to be on the tank.

11. Pour the color developer into the open processing tank and start the timer or write the time on a piece of paper. Agitate the tank 5 seconds every 30 seconds.

12. When you reach the desired processing time, pour the color developer into its storage bottle through a clean funnel.

13. Reset the timer or cross out the time on your piece of paper.

14. Repeat step 9, filling the processing tank with water at the same temperature as the other solutions, agitating the filled tank for 30 seconds, and then draining it. Repeat this cycle four times.

15. Once the washing is finished, reset the timer or cross the time off the piece of paper.

16. Pour the bleach/fix solution into the processing tank. Start the timer or write the time on a piece of paper. Agitate the tank 5 seconds every 30 seconds. The film should stay in the bleach/fix solution for 10 minutes.

17. Once the bleach/fix phase is complete, pour the solution into its storage bottle through a clean funnel.

18. Reset the timer or cross out the time on your piece of paper.

19. Fill the processing tank with water at the same temperature as the other solutions. Start the timer or write the time on a piece of paper. Agitate the filled tank briefly and then drain it. Repeat the fill-and-drain cycle at least six times in 4 minutes.

20. Once the washing is finished, reset the timer or cross out the time on your piece of paper.

21. Pour the stabilizer solution into the processing tank. Start the timer or write the time on a piece of paper. Agitate for the first 5 seconds *only*. Leave the film in the stabilizer solution for 1 minute.

22. Once the stabilizing time is up, pour the stabilizer solution into its storage bottle through a clean funnel. Reset the timer and put it away.

23. Use a sock hanger to hang the top of the film on a hook and a matching one to act as a weight on the bottom of the film. Hang the film in a dry, dust-free place.

Don't evaluate your slides while they are wet, because the emulsion dries to a somewhat different color. Once dry, however, the slides can be mounted in cardboard or plastic slide mounts. I prefer plastic slide mounts because they look a little classier and they're tougher and last longer too.

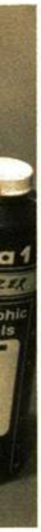
Pushing and Pulling Film

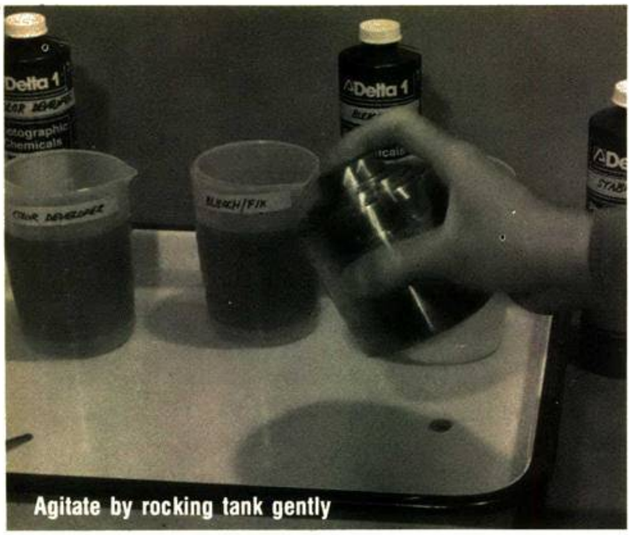
One of the chief benefits of processing color slides yourself is that you can partially compensate for errors in exposing the film. What if you took a 1/30-second exposure of the Moon when you should have used a 1/125- or 1/60-second exposure? Or what if you thought you had Ektachrome 200 in your camera for those shots of Mars, took the exposures accordingly, and then found out you had Ektachrome 400 in the camera? "Pulling" allows you to decrease the film's speed by as much as two stops (a factor of four) during processing.

"Pushing," on the other hand, works the opposite way — it increases film speed by as much as three stops (a factor of eight). Imagine you and a friend each take a photo of the Orion Nebula with the same instrument, the same exposure time, and on the same night. Your friend processes his slide normally and finds very little nebulosity. How can you salvage your shot?

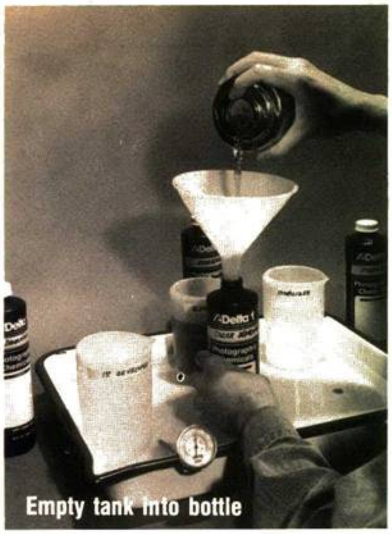
Suppose both shots were for 10 minutes at f/5 on Ektachrome 200. Ideally you would have taken a longer exposure than your friend did so you could record more nebulosity. If you push your slide by one stop during development, it would be theoretically the same as taking a 20-minute exposure of the Orion Nebula. Pushing your slide by two stops would be the same as using a 40-minute exposure. These are ideal values and do not compensate for the film's inability to retain its rated film speed when exposed to low light levels for a prolonged period of time. However, pushing *will* produce more nebulosity.

Pulling and pushing simply require changing the processing time of the first developer. Pushing requires overdeveloping the film and so involves a longer developing time, while pulling involves shortening the developing time. Pushing by three stops also *requires a longer time in the color* developer, and the color developer must be diluted to a total volume of 1,600 milliliters.

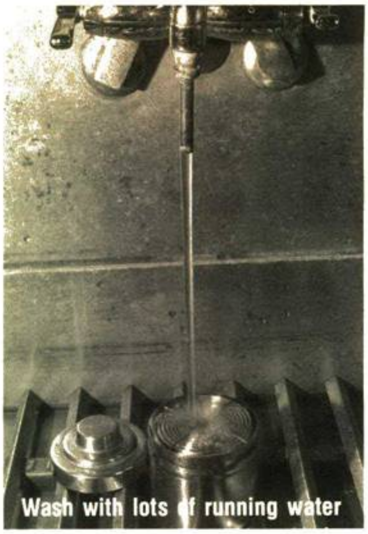




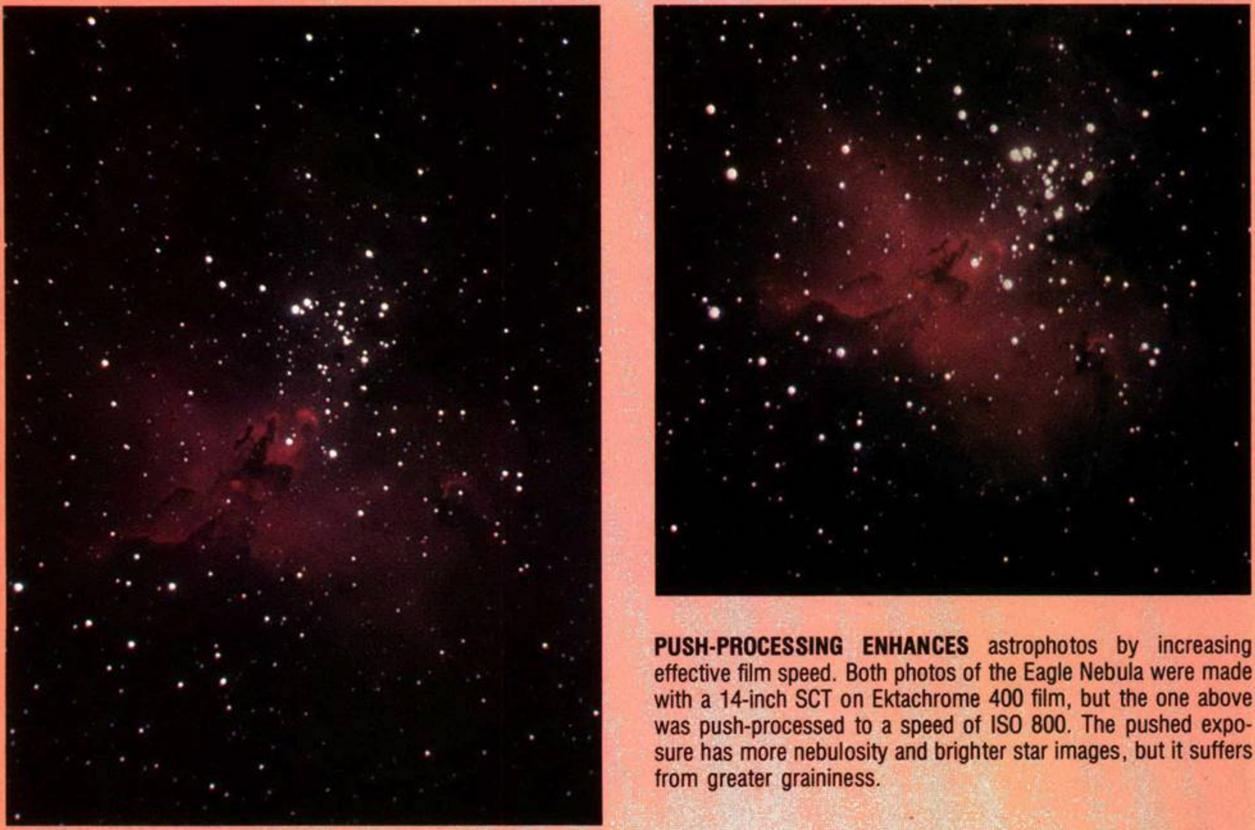
Agitate by rocking tank gently



Empty tank into bottle



Wash with lots of running water



PUSH-PROCESSING ENHANCES astrophotos by increasing effective film speed. Both photos of the Eagle Nebula were made with a 14-inch SCT on Ektachrome 400 film, but the one above was push-processed to a speed of ISO 800. The pushed exposure has more nebulosity and brighter star images, but it suffers from greater graininess.

A full explanation of push/pull processing is given, along with the appropriate time/temperature table, on pages 11-13 of the kit manual.

Unfortunately, image quality suffers when you use push or pull processing. Film quality is optimized for the film's rated speed, and pushing or pulling changes that speed. The loss in quality is more pronounced for pulling — there is more grain, lower resolution, and weaker blacks — but the same defects also appear in push processing. These problems may partially offset the advantages of pushing and pulling, but by processing your own film, the choice, at least, is yours.

Doing your own film processing is inexpensive and relatively fast. It gives you the ability to see finished slides quickly and to compensate for some mistakes in exposure. And you shouldn't be intimidated by color — with today's technology, color slide processing is not only safe but easy, and it can be done at a wide variety of temperatures. At-home processing means you'll never be "blue" again because someone else botched your film processing. And your fellow astrophotographers will be "green" with envy when they see your color processing results! ☐

Rick Dilsizian is an assistant professor of mathematics and computer science at Westchester Community College in Valhalla, New York. His most recent article in ASTRONOMY, "Filters for Better Astrophotos," appeared in the July 1988 issue.

DUST STORMS OBSERVED ON MARS

Dust storms swept across the surface of Mars during May and June 1988, according to Jeff Beish, Mars Recorder for the Association of Lunar and Planetary Observers (ALPO). Several United States observers spotted these storms, and Beish feels this activity suggests that a major dust storm may occur later this year.

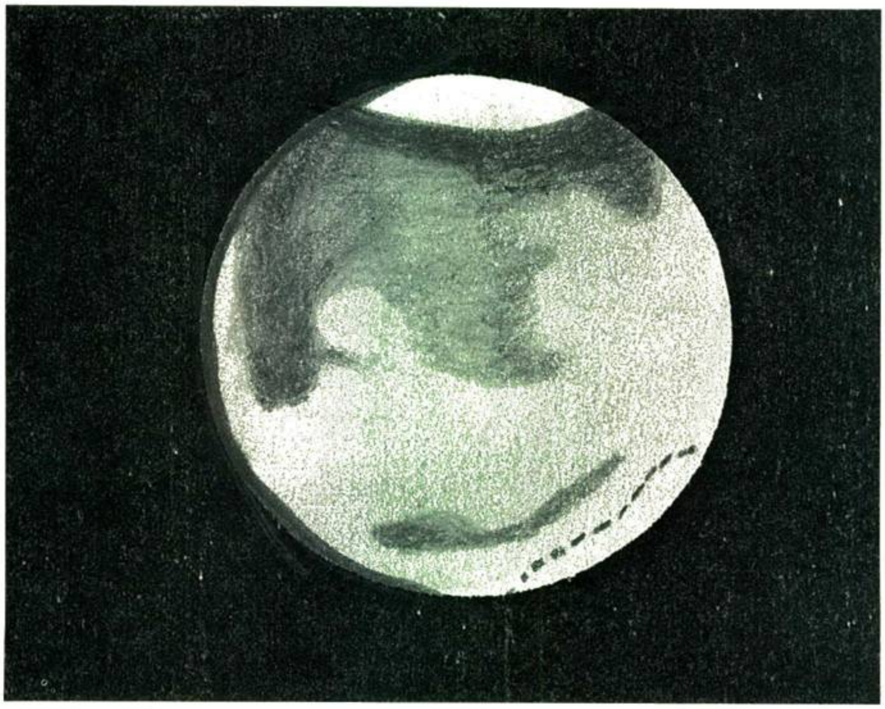
"A yellow cloud was observed in the Hellas plains from May 5 through 7, 1988," Beish reported. "Yellow streaks beginning at Hellas and extending northwest through Deltoton Sinus and northeast into Libya were observed in early May. At this time a dull yellow haze extended northwest over Sabaeus Sinus and west into the Noachis region."

This year Mars is proving to be interesting to watch. "Solis Lacus is again an area of change," Beish continued, "as it has been during other years of Martian opposition. This year the region appeared to be covered by dense clouds as it crossed the planet's morning limb in mid-April." During the same period Frank Melillo of New York and Dan Troiani of Chicago both reported seeing Solis Lacus "dull and washed out." Throughout the spring observing season Beish and fellow ALPO observer Don Parker reported that the Ganges region, in contrast to Solis Lacus, appeared very broad, dark, and well defined.

Mars also appears to be showing surface activity other than dust storms. During the 1950s ALPO observers reported seeing "canals" called Hydraotes, Lysis, and Nilokeras II, which are connected to the regions known as Oleaster Lacus and Lunae Lacus. The canals appear to be thin, dark lines on the planet's surface. This year the canal-like features have again darkened and become visible, although good seeing is required to spot them.

The Martian southern polar cap has also undergone changes. On June 3, 1988, Beish and Parker reported seeing a rift that separated the southern polar cap from Novissima Thyle. Beish predicted that the rift should continue to grow. When it is large, the rift is known as the Rima Australis.

Beish believes Mars will continue showing dust storms and other surface activity as the planet moves through opposition this month. Observers who wish to report their observations to ALPO can write Beish at Box 97-0469, Miami, FL 33197.



DUST STORM OVER SOLIS LACUS on Mars causes the region, near the center of Mars' disk, to appear fainter than usual. Dan Troiani of Schaumburg, Illinois, made this sketch on May 27. He used a 10-inch f/6 reflector at 374x.

OBSERVING METEORS ON A NIGHT DOWN UNDER

Observing the sky from down under is an unbeatable experience for backyard astronomers, according to M. L. Clark of Armadalke, Western Australia. Clark is so proud of the southern sky that he offers to act as an ambassador of Australian amateur astronomy and meet visiting amateur astronomers. Clark sent the following description of observing the sky on a typical Australian night.

"It was May 7, 1987, and James Athanason, Andrew Pearce, and I traveled to the town of Broome for an observing expedition. Each of us went for a different reason. Andrew wanted to observe comets. James wanted to take deep-sky astrophotographs. I eagerly awaited the Eta Aquarid meteor shower.

"We began by looking at Comet Wilson in James' 5-inch refractor. Wilson was an old friend. We had been observing it for several months and on this night it was an impressively bright object even though the Moon was in the sky. We observed two 2°-long tails and suspected a third, much fainter tail. The Moon prevented us from spotting Comet Grigg-Skjellerup, so we switched to observing the supernova in the Large Magellanic Cloud. We were all becoming a bit bored with the supernova at this point, because the supernova had been brightening only very slowly over the previous several weeks. It appeared to shine at about magnitude 2.9.

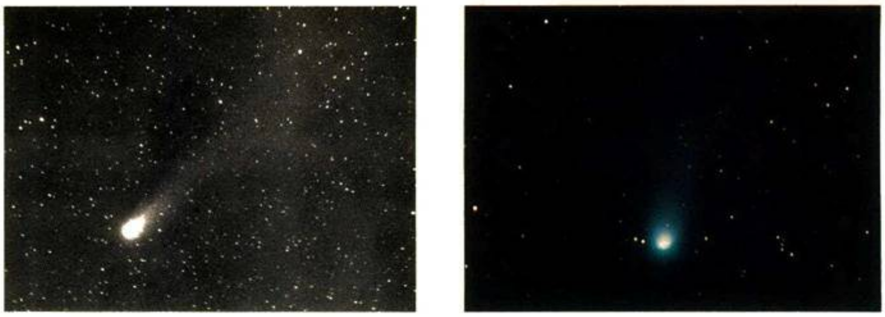
"At last the Moon set and the stars stood out in their full splendor. We could see magnitude 6.9 stars with the naked eye and the zodiacal light was clearly visible across much of the sky. The center of the Galaxy lay overhead, offering stunning star clouds and dark rifts. But we had other things on the agenda that night.

"By now the Eta Aquarid meteor shower radiant was above the horizon, so I began watching for meteors. The first one I saw was a long, greenish meteor shining at about magnitude −1. Others quickly followed, and by the end of the first hour's observing I had logged seventy-nine meteors, including thirty-seven Eta Aquarids. This was a fantastic rate, so James joined me during the second hour.

"Over the next hour we observed a total of ninety-one meteors, of which fifty-one appeared to be Eta Aquarids. Of these a high proportion were bright meteors that left faint trains. Suddenly a −2-magnitude Eta Aquarid appeared near where Andrew was observing Comet Sorrells. He called me over to check on the comet. Did it have a faint tail? I felt it did, but Andrew was not so certain.

"We kept observing comets and meteors all night long. It was incredible how fast the night slipped away. The final half hour was hectic. I observed thirty-nine Eta Aquarids out of sixty-five meteors, and James spotted fifty meteors. Eagle-eyed Andrew saw eighty meteors. On several occasions we saw two Eta Aquarids simultaneously.

"The Sun rose. After some sleep we headed for the beach. The magnificent skies, the abundance of comets, and the hoards of meteors made this night an unforgettable experience."



COMET LILLER was a naked-eye object visible all night last May. Geoff Chester photographed the comet (left) from Rixeyville, Virginia, on May 13. He used a 5.5-inch f/3.6 Schmidt-Newtonian, hypered Tech Pan film, and a 20-minute exposure. Maurice Salaman's photo (right), taken April 18, shows the comet's bright inner coma. Salaman used a 20-inch f/3.8 reflector and Fujichrome 1600 film to make this 8-minute exposure from Pui Michel in southern France.

COMET LILLER BRIGHT LAST MAY

During the first days of May 1988, Comet Liller (1988a) put on an impressive show in the northern sky and remained visible all night for viewers in the Northern Hemisphere. The comet shone at around 5th magnitude (some estimates placed it at as bright as 4th), and many observers who saw Liller under a dark sky thought it rivaled Halley's Comet.

Observers at the Texas Star Party were amazed to see the comet with the naked eye during the week of May 8-15. Small telescopes showed a bright coma with a stellar nucleus surrounded by a large diffuse halo of greenish gray light. The comet sported a 3° tail that was 30′ wide, evenly illuminated, and disappeared in a rich starfield.

"I never dreamed you could see a comet that well," said Jessica Mackinnon, membership coordinator of the Adler Planetarium in Chicago. "It was as if we were orbiting the comet in a spaceship!" Members of the planetarium visiting the star party viewed the comet with a 24-inch reflector. The typical reaction: "That view alone was worth the trip."

Nearly everyone at the star party compared Liller with Halley's Comet, which disappeared from view late in 1986. In reality Comet Liller may not have been quite as bright as Halley, but Liller was better placed for observing. Most important, observers seemed overjoyed to have a bright comet in the sky again.

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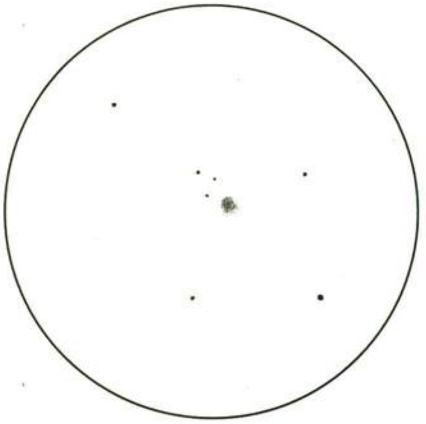

COMET TEMPEL 2 GLOWED SOFTLY when this sketch was made on May 17. Don Pearce sketched the comet at the Texas Star Party using his 17.5-inch f/4.5 reflector at 154x.

COMET TEMPEL 2 BRIGHTENS TO VISIBILITY

While most observers were enjoying views of Comet Liller, a few comet hunters began searching for the extremely faint — but gradually brightening — periodic Comet Tempel 2 (1987g). This comet returns to perihelion at five-year intervals, and normally it is relatively dim. This year's apparition is a favorable one, however, and by early May Tempel 2 was faintly visible in large telescopes at about 14th magnitude.

Don Pearce of Bellaire, Texas, observed Tempel 2 at the Texas Star Party and thought it was "at the very limit of my 17.5-inch telescope." Pearce observed Tempel 2 at 154x and recorded that the comet "appeared diffuse with no central condensation. The diameter of the coma was approximately 1′ and the entire comet appeared extremely faint. Larry Beatty of the Oklahoma City club confirmed this observation using a 24-inch telescope and detected the comet's motion."

DEEP SKY PHOTOGRAPHY FROM SUBURBIA

"Head for the country!" is the rallying cry of serious astrophotographers. Almost everyone knows you need a velvety black sky to take impressive photos of faint nebulae and galaxies — right? Rick Schrantz of Nicholasville, Kentucky, doesn't think so. Schrantz has been taking top-notch photographs of deep-sky objects from his home just three miles outside of Lexington, a city of 205,000.

"From my driveway," Schrantz explained, "the summer Milky Way is barely visible. I recently bought a 10-inch f/10 SCT and really wanted to photograph deep-sky objects. I also bought a guider with a built-in focal reducing lens — enabling me to choose f/10, f/6.2, or f/5 — and a Deep Sky filter. This combination darkens the sky background and allows me to take reasonably nice pictures. I do not have a home hypering kit or a darkroom. I buy hypered film through the mail and all of my prints are processed at the local one-hour photo store.

"I was surprised that deep-sky astrophotography can be done from a moderately light-polluted site. Before trying it myself, I would have guessed that dark, desert skies, huge telescopes, and a home darkroom were prerequisites for astrophotography. That just isn't so."

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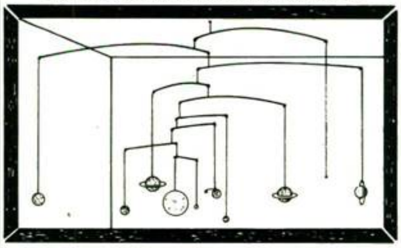

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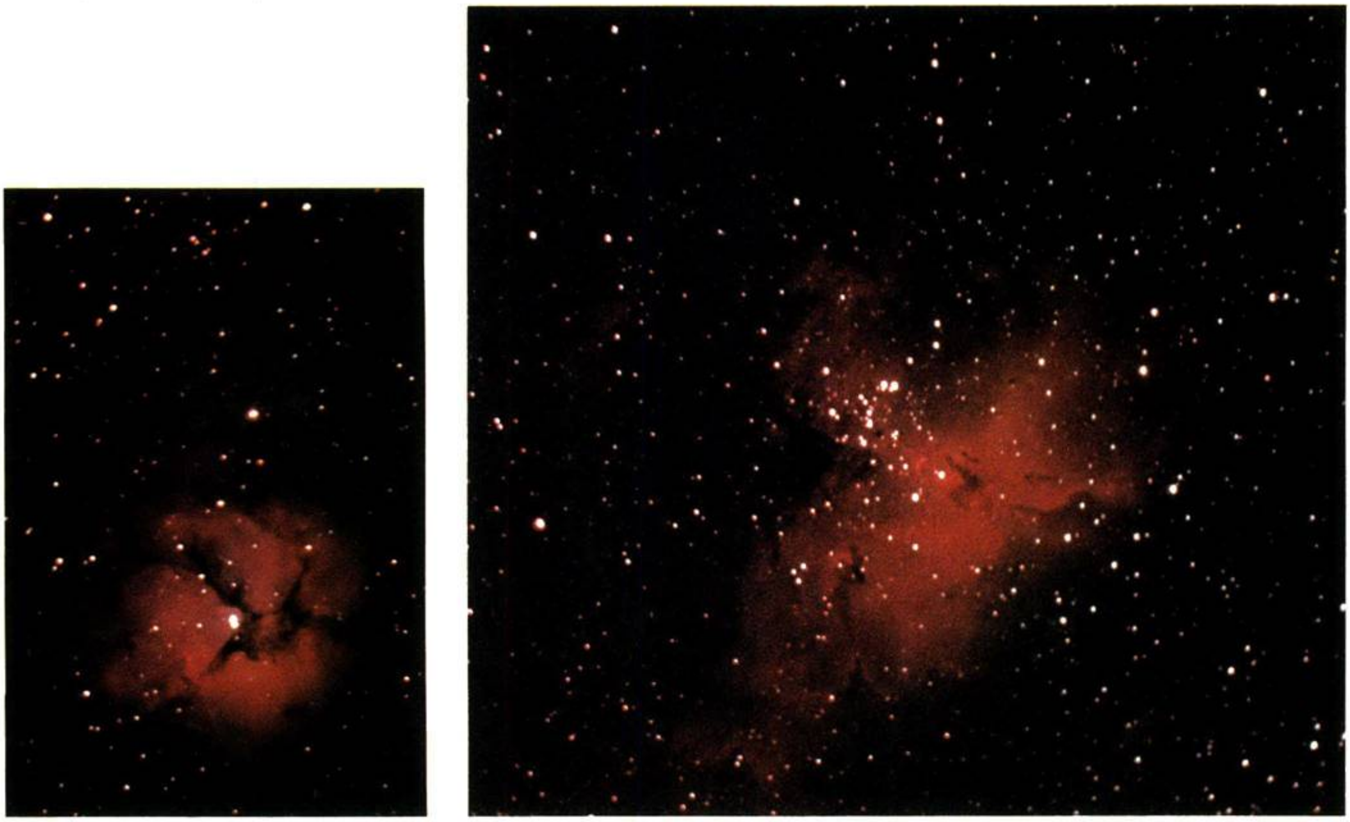

SHOT FROM SUBURBIA, these photographs of the Trifid Nebula (left) and the Eagle Nebula (right) were made three miles from Lexington, Kentucky. To reduce light pollution, Rick Schrantz added a Deep-Sky filter to his 10-inch SCT astrophoto system. The Trifid Nebula shot is a 30-minute exposure at f/10 on hypered Konica SRV 3200 film. The Eagle Nebula photo is a 25-minute exposure at f/6.2 on hypered Konica 3200.

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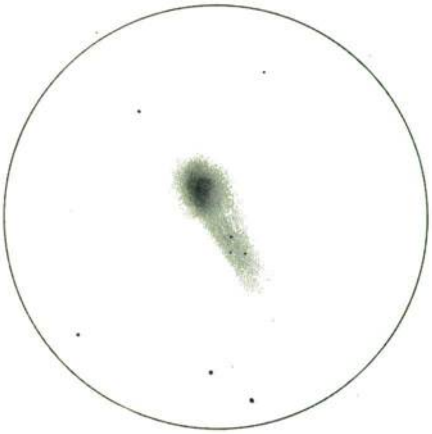


COMET McNAUGHT ($1987b_1$) was sketched by twelve-year-old Linwood Watson of Kenly, North Carolina, on January 29, 1988. Watson used a 6-inch reflector at 23x. At the time this sketch was made, Comet McNaught glowed softly at 7th magnitude. Robert McNaught of the Siding Spring Observatory in Australia discovered the comet on October 9, 1987.

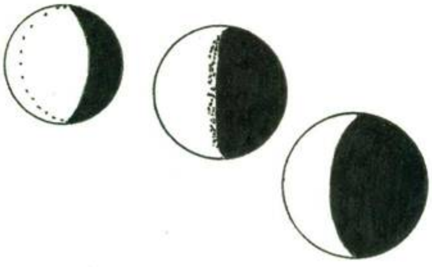
OBSERVING MERCURY IN BROAD DAYLIGHT

Can Mercury be seen in broad daylight? Marc A. Gelinas of Ile-Perrot, Quebec, wrote, "For years I have tried to find Mercury in the daylight when the planet is high above the horizon, but I've always failed. On May 7, 1988, I tried again and was rewarded with an unforgettable view. I began by aiming my 6-inch f/12 apochromatic refractor at Venus, which was easily visible. I adjusted the focus and noticed that the seeing was very steady.

"Using a wide-angle eyepiece that provided a magnification of 76x, I moved the telescope to Mercury's coordinates. The time was 4:45 p.m., the sky was dark blue, and Mercury appeared in the eyepiece after a few seconds of sweeping. The planet was also visible in my 60mm guide scope, but not in the finder scope.

"For the rest of the month I was able to follow the phases of Mercury in the daytime sky. I didn't see any detail on the planet, but I did see a bright limb and a slightly darker region near the terminator. Mercury's disk appeared creamy white or ivory. As Mercury's magnitude decreased during the month, the planet became harder and harder to see in the guide scope but remained easy in the 6-inch refractor."

Are there tricks to spotting Mercury in the daytime? Gelinas wrote, "The keys to finding Mercury are good polar alignment, accurate setting circles, and sharp focus. I also found that yellow (Wratten #15) or orange (Wratten #21) filters helped to increase the contrast against the bright sky." — *David J. Eicher* ☐



MERCURY IN DAYLIGHT appeared as a slowly growing crescent throughout May. Marc A. Gelinas of Ile-Perrot, Quebec, sketched the planet on May 7, 13, and 20 (left to right) with his 6-inch f/12 refractor at 366x. To improve contrast, Gelinas used yellow and orange filters.

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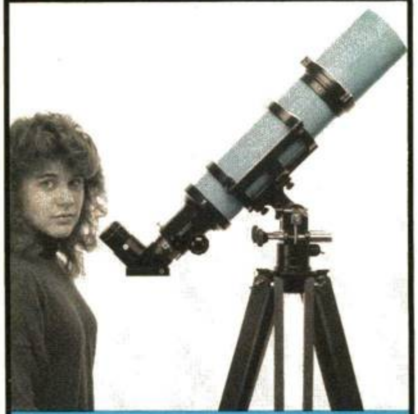

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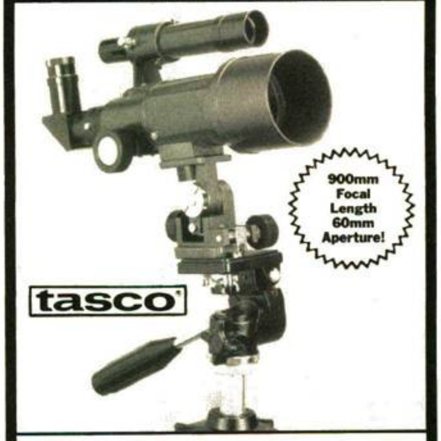

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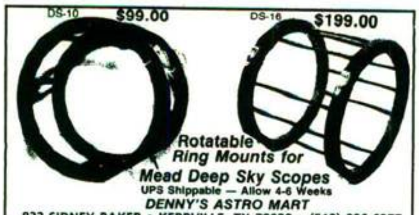

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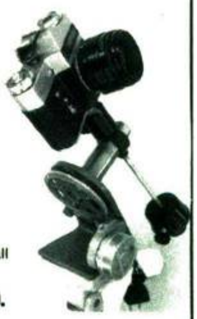

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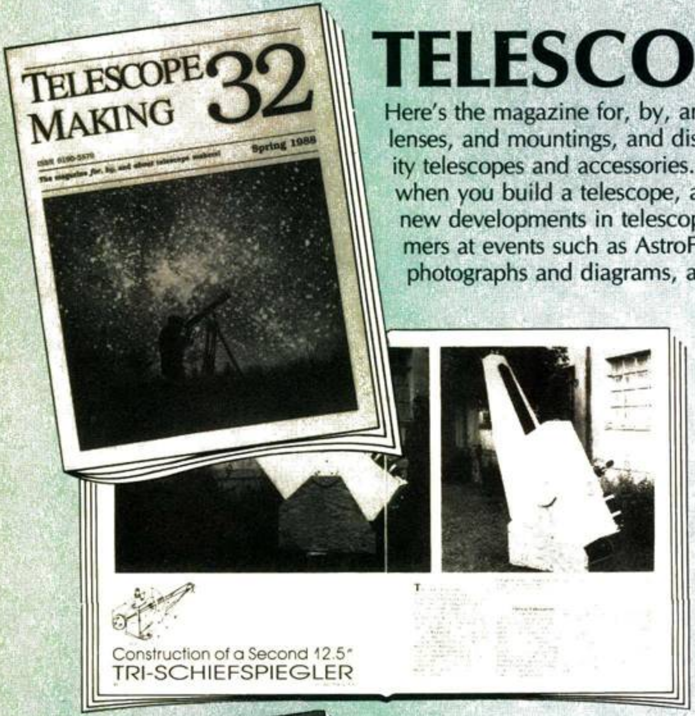
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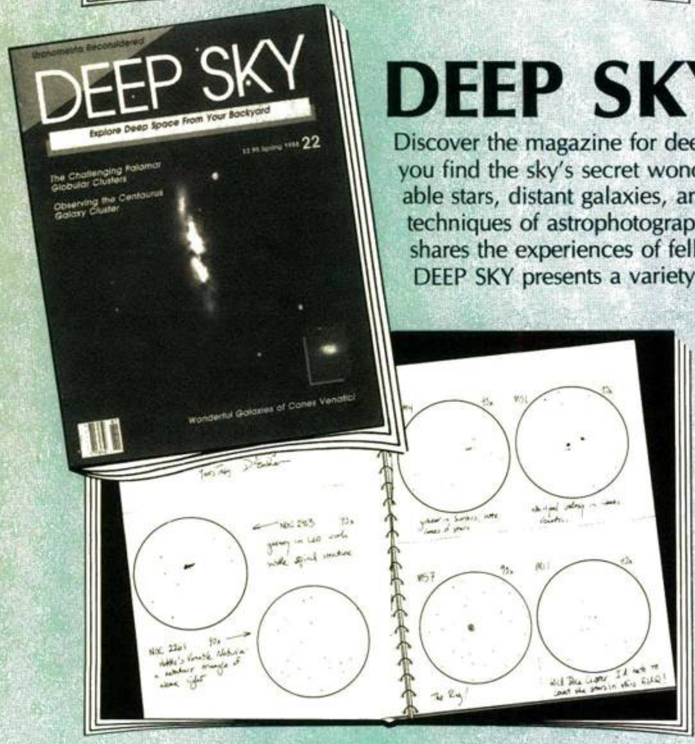
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SILVER METEORS ON A LAVENDER SKY

Somehow I managed to load a reclining lawn chair, a sleeping bag, a star chart, and a hand-operated counter on my ten-speed bicycle and ride two miles to the house of my friend, Joey Sweet, who lived outside of Esperance, New York. We were going to camp out in the fields beyond Joey's house to watch the 1986 Perseid meteor shower under a dark sky.

Scouting for the right field turned out to be quite a safari. The fields were some distance from Joey's house, and we had to bushwhack through woods, a marsh, and numerous wild thorn bushes to get there. This was when I discovered that Joey is terrified of wild dogs. He swore dogs roamed through the fields at night and attacked people, and he was prepared to bring an array of shotguns with him if we decided to camp there. It was obvious we would do no meteor watching from those fields, so we returned to Joey's house.

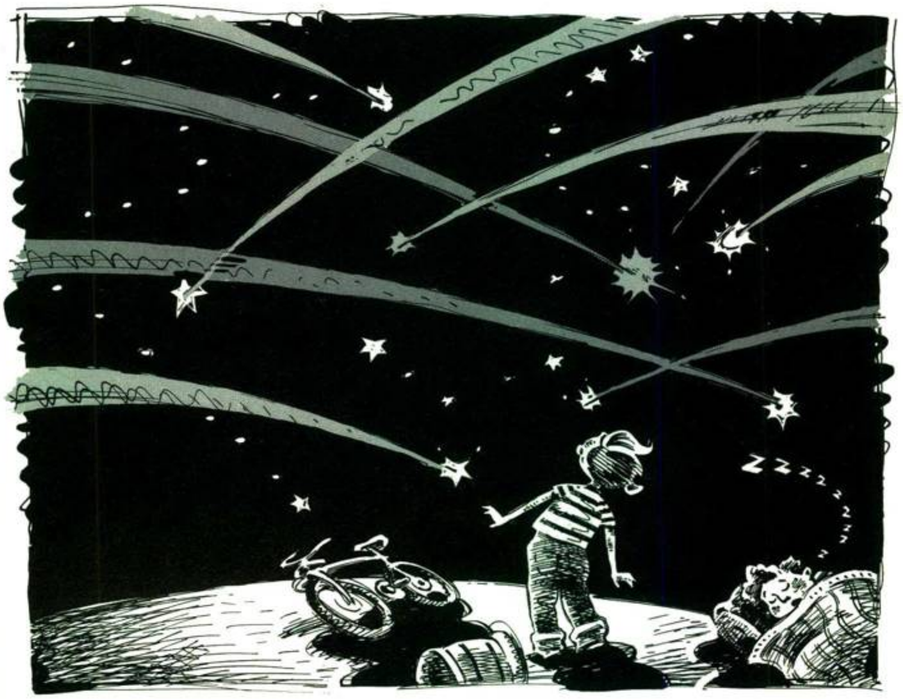
We were lying on his front lawn when we saw our first meteor. It was a silver streak against the lavender sky. It was so short-lived that its brief existence would only be known to the few people who had looked up at the sky at just that moment. After this preview of the shower we resolved to find an open area with a better view of the sky but away from the wild dogs.

Eventually we decided on a field only a short running distance from several houses, in case wild dogs attacked. We lay in our lawn chairs, tucked comfortably in our sleeping bags. The Moon had set, and the sky was now diamond-studded. Slowly the constellations marched across the sky in a procession set to the music of the crickets, peepers, and the whispers of the wind. I had never seen such a perfectly clear night.

Then the show began. Each meteor I spotted left me eager for the next one. The meteors became more numerous as the night progressed, increasing to two or three per minute.

With the first hint of dawn in the northeast the meteors scurried about the sky playfully in a game of hide-and-seek among the stars. Orion the mighty hunter rose in the east above the dewy meadows and the vast sea of fog in the valley below. About that time Joey, who had fallen asleep, woke up. Exhausted from the night's vigil, I reloaded my bike and made my way down the dimly lit road to my house.

The 256 Perseid meteors I had seen were my reward for staying up all night.
— *Bryon Lawrence*



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I looked across the classroom at sixty or so third-grade children packed like stars in a globular cluster. Each face had a different shape and color and features that made it different from all the others. Some faces were sprinkled with a Milky Way of freckles, a few had a not-so-mysterious black hole where two front teeth had been, and others had eager, glowing smiles not unlike the soft glow of a distant nebula.

I was speaking to these students as part of Tennessee Space Week, a project jointly sponsored by the Tennessee Education Association and NASA. Activities varied from school to school and ranged from my talk about astronomy to a speech that addressed man's future habitation of Mars.

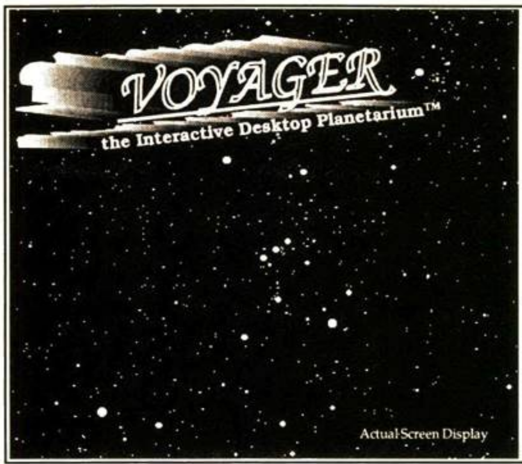
My intention was to use about forty-five minutes of class time, but after a fierce volley of questions (several from the teachers), almost twice that much time had elapsed. My presentation had the usual components: tips on observing; stories about comets, planets, and meteor showers; and some hands-on items such as star maps, field guides, binoculars, and fingerless gloves.

As I moved along with my skylore talk, little hands and big questions were raised and I realized what great potential might lie within the confines of that room: the keen mind of a Stephen Hawking, the courage of a Christa McAuliffe, or even the genius of an Albert Einstein. I realized how easily I could ignite the flame of curiosity in a young mind.

My tale of the great hunter Orion with his faithful, bright-eyed dog tracking the ever-elusive bull was the hit of my presentation. My short, simple homework assignment was to hunt the great hunter that night.

I didn't realize then how the students would respond to my request. A week later my wife, who teaches at that school, greeted me with a stack of raggedy notebook paper when I arrived home from work. "I brought you some letters from your astronomy friends," she explained. As part of an assignment on proper letter form, one of her classes had written letters to me. What had been a good experience suddenly became a great experience because of the "fan mail" I received.

Some of these letters are worth sharing. Although I have condensed some of them, the sentence structure, spelling, punctuation, and grammar remain unedited and are, therefore, forever in the original, innocent style of the writers. I've



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added interpretation in brackets where it's needed.

The first, nearly nonstop letter was a gem.

Dear Mr. King:

I very much enjoyed watching your show it was very good and you know what you said about M47 or something like that [actually, M42] well Jessica spent last night with me and we saw M47 it was buataful and I saw that orzo guy [Orion] and his dog and I saw the red star and the white star and Jupeter.

I though the milky way was very neet I want to see the reall thing I think I'll get into space.

Yours Truley,
Kimberly

There's nothing particularly impressive about this next one, except that it came from the heart. And that's good enough for me.

Dear Mr. King,

I saw Ryjo [I think he means Rigel] that Night. I was really neat. I like the name Beetle Juice, did you ever go to the theatre and tell them about it because there's this show called Beetle Juice.

Your friend
Brandon

I saved the best for last. You may want to remember Beth Rainwater. We may hear about her again someday.

Dear Mr. King,

I enjoyed when you came to our class. It was very interesting. Monday, I wrote a report on the Milky Way Galaxy. I read why the Milky Way is called a Spiral galaxy. It is because stars, dust, and gases fan out in the central bulge in long, curving arms that form a spiral pattern. And that the flat part of the disk contains young stars, irregular shaped groups of stars called open clusters. I also read that the Milky Way is about 100,000 light years wide. Our Solar System is on the edge of the Milke Way. I very glad you came, because now I want to know more, and more about space.

Your Space learning friend,
Beth

No matter what your hobby is, it is enjoyed most when it is shared with others, especially children.

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*Astronomy Magazine, 10/84

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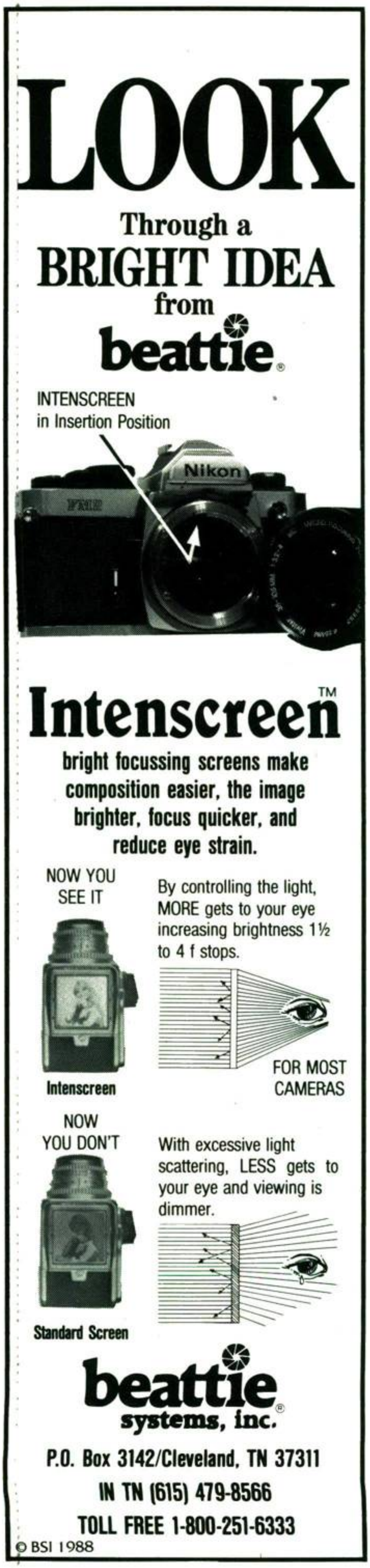

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A SOUTHERN SKY TABLEAU

Exploring the Southern Sky by Svend Laustsen, Claus Madsen, and Richard M. West, (Springer-Verlag, 1987), ISBN 0-387-17735-3, hardcover, 274 pages, $39.

More observatories should put out books like this. Subtitled "A Pictorial Atlas from the European Southern Observatory," this work is primarily a picture book of the sky that emphasizes objects visible from mid-southern latitudes, but it also includes a few northern objects and an informative and accessible (if somewhat choppy) text written at an introductory level. The result is a very pretty book that will appeal to astronomy buffs in every latitude.

The book obviously focuses on pictures, and these are presented in an orderly manner. In the first of the book's four chapters we see how galaxies are classified and several examples of each kind. (For simplicity the arrangement uses the Hubble "tuning fork" classification system, though the text also refers to other systems.) We next turn to members of the Local Group galaxy cluster (to which the Milky Way belongs), the Sculptor Group (a cluster of galaxies best visible from the Southern Hemisphere), and some of the nearer clusters such as the Virgo and Coma groups.

Alongside this cluster-probing, we encounter a selection of "pathological" galaxies — two or more galaxies that have passed near one another, which has distorted their shapes with mutual tidal forces — and peculiar galaxies, the history of which is sometimes fairly obvious and sometimes anyone's guess.

The book's second chapter — the one I liked most — covers the Milky Way Galaxy. One of its best features is a gorgeous panorama of the entire Milky Way — northern and southern — spread across two pages. The panorama is a seamless mosaic of eight frames taken with a Hasselblad Super Wide Camera at La Palma Observatory in the Canary Islands and at ESO's facility at La Silla, Chile. This camera uses a 38mm lens on 120-format roll-film, which is equivalent to using a 20mm lens with 35mm format. The individual photos and the mosaic as a whole are magnificent.

With Orion at its left and right edges the panorama sweeps through the northern constellations on the left-hand page and then below our southern horizon a few inches to the right of the book's gutter. In this hidden section lie all those good things such as Crux and the Coalsack, Eta Carinae, and the Large Magellanic Cloud, which remain denizens of the printed page for us northerners instead of being eyepiece sights. But, best of all, the panorama is printed twice as big on a special fold-out sheet tucked inside the back cover.

With this grand view *firmly* in the reader's consciousness, the book then looks in great detail at various interesting regions: Orion, Vela-Carina, Crux and Norma, and so on. These regions are full of nebulae, clusters, dust clouds and new stars, wispy supernova remnants, and the like. Each page, it seems, contains a stunning astrophoto and the text carefully explains what we are seeing. And the close-up photos! They're the real thing for

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A Pictorial Atlas from the European Southern Observatory (ESO)
Springer-Verlag

any image junkie: I repeatedly found myself gazing at the tiny details in the dust clouds.

The third chapter deals with minor bodies in the solar system, including a good selection of Comet Halley pictures. The Halley shots are some of the best. Still, this section is the weakest of the whole. It's not the book's fault that asteroid trails are simply little white worms on a grainy plate. Nonetheless, these pictures cannot invite that leap of imagination that puts you deep in the Eta Carinae Nebula in chapter two.

The last chapter is on ESO itself, both its offices and laboratories in Munich and the La Silla field station with its 3.6-meter main scope. I suppose it's mostly institutional bragging to include these pictures, but the high Andes offer some very photogenic landscapes and it is nice to see the instruments that took the shots in the book. You also get a good idea of what it's like to work as an astronomer where thousands of miles separate your instrument from your home office.

The text accompanying the photos is written at a fairly basic level, but it satisfactorily explains the main phenomena visible in the photos. There isn't a formal index, but the glossary contains page references and the visuals themselves function as an index of sorts.

The production qualities are excellent: color photos (which make up about 40 percent of the images) are in sharp register and the sky backgrounds are black. Most images are conventional photographs. However, images made with a charge-coupled device (some with false-color enhancement) are used when they show more than an ordinary photo would.

Somewhat more than half the black and whites are printed in negative (black stars, white sky). The incredible detail that can be seen in these images makes them worth scrutinizing. In general the placement and cropping of photos are quite good, and pretty "showstoppers" usually get a full page to themselves. The orientation for each photo is the same (north at top), which is a minor but welcome touch. Last, for camera buffs, an appendix lists each plate and gives the right ascension and declination of its center, the instrument it was taken with, the exposure time and emulsion, the plate scale, and even the observer.

I mentioned text choppiness, but this may be more apparent to the reviewer who must sit down and read an atlas cover to cover than to the ordinary reader. There is an average of one plate per page, and getting enough space for an informative caption occasionally creates layout problems. Most owners of this book, however, will leaf through it, stopping and reading the text whenever a photo catches their interest. For these people the choppy text problem simply won't exist (and in any case, you never lose the continuation of what you're reading).

The obvious picture book to compare this one with is *Galaxies* by Timothy Ferris. I think the new book easily surpasses *Galaxies*, both in text and photography. More importantly though, *Exploring the Southern Sky* covers a far wider variety of objects and does it with entirely fresh images, many of which weren't available until the last couple of years.

This is a fine book for any astronomy buff's library. — *Robert Burnham*

A HIP-POCKET GUIDE TO THE STARS

The Peterson First Guide to Astronomy by Jay M. Pasachoff, (Houghton Mifflin, 1988) ISBN 0-395-46790-X, paperback, 128 pages, $3.95.

When a novice stargazer first looks up at the night sky, he is liable to be overwhelmed by what appears to be thousands of randomly placed stars. His first thought might be: How can one possibly learn the positions and names of all those stars? Determination is a step in the right direction, but what would really help is a clearly written handbook with easy-to-read star maps that fits nicely in the hip pocket. *The Peterson First Guide to Astronomy* is just such a book.

Responding to readers who wanted a simpler, more straightforward guide to nature than one of the thirty-six-title Peterson Field Guide series, the Houghton Mifflin Company developed an offshoot series called "First Guides." *The Peterson First Guide to Astronomy* is the first of the series to be released this year.

Like *A Field Guide to the Stars and Planets* (Houghton Mifflin, 1983), written by Pasachoff and Donald Menzel with maps by Wil Tirion, the *First Guide*'s main attraction is the maps that show how the stars appear throughout the year. The *First Guide* maps, though not as detailed as the *Field Guide* maps, are sufficient to direct the beginner to the main points of interest in the night sky. The design premise is that beginning starwatchers do not want very faint stars and innumerable deep-sky objects cluttering the big picture.

To use the maps, you simply face north or south at the dates and times indicated. The maps show white stars on a dark blue background; this makes them easy

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to read in the dark if you use low illumination. The faintest stars shown are 4th-magnitude, which is about the naked-eye limit on the outskirts of most suburban areas. Selected bright deep-sky objects are plotted for observers with binoculars or small telescopes.

Following the maps is a section called "Meet the Constellations," which describes fourteen prominent constellations and their mythology. The facing page is illustrated with Robin Brickman's white-chalk drawings of the mythological characters.

The second half of the book describes the universe in a nutshell: star clusters, nebulae, supernovae, black holes, galaxies, and the solar system are each explained in two pages. The book concludes with page-long chapters on telescopes, time, and calendars.

Don't expect the text to answer all of a beginner's questions about astronomy: though it's well written and easy to follow, the book is clearly designed to be an astronomy "sampler," not a resource. The maps will undoubtedly be useful, especially packaged in a handy grab-it-and-go paperback. *The Peterson First Guide to Astronomy* is an excellent beginner's handbook for backyard observers with fairly dark skies and a desire to learn a little about what the universe has to offer. — *Jeff Kanipe*

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Lines to the Mountain Gods: Nazca and Mysteries of Peru by Evan Hadingham, (University of Oklahoma Press, 1988), ISBN 0-8061-2130-0, paperback, 307 pages, $15.95.

Surveyors of the Ancient Mississippi Valley: Modules and Alignments in Prehistoric Mound Sites by P. Clay Sherrod and Martha Ann Rollingson, (Arkansas Archeological Survey Research Series No. 28, Box 1249, Fayetteville, AR 72702-1249, 1987), ISBN 0882-5491, paperback, 151 pages, $10.

COSMOLOGY

Beginnings: The Story of Origins — of Mankind, Life, the Earth, the Universe by Isaac Asimov, (Walker and Company, 1987), ISBN 0-8027-1003-4, hardcover, 284 pages, $19.95.

The Quickening Universe: Cosmic Evolution and Human Destiny by Eugene F. Mallove, (St. Martin's Press, 1987), ISBN 0-312-00062-6, hardcover, 268 pages, $16.95.

PHYSICS

The Concepts of Science: From Newton to Einstein by Lloyd Motz and Jefferson Hane Weaver, (Plenum Press, 1988), ISBN 0-306-42872-5, hardcover, 435 pages, $23.50.

The World of Physics: A Small Library of the Literature of Physics from Antiquity to the Present, three-volume set, by Jefferson Hane Weaver, (Simon and Schuster, 1987), ISBN 0-671-64216-2, hardcover, 2,948 pages, $89.85.

RADIO ASTRONOMY

Galactic and Extragalactic Radio Astronomy, second edition, edited by G. L. Verschuur and K. I. Kellermann, (Springer Verlag, 1988), ISBN 0-387-965755-0, hardcover, 678 pages, $79.95.

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Astronomical Observations: An Optical Perspective by Gordon Walker, (Cambridge University Press, 1987), ISBN 0-521-33907-3, paperback, 347 pages, $29.95.

SOLAR SYSTEM

The Physics of the Planets: Their Origin, Evolution, and Structure, edited by S. K. Runcorn, (John Wiley & Sons, 1988), ISBN 0471-91621-8, hardcover, 456 pages, $135.95.

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Meetings and Events

September
"Month of Mars," Gastonia, North Carolina. Events held throughout the month. Contact: Larry L. Benfield, Gaston Amateur Astronomers, Schiele Museum and Planetarium, P.O. Box 953, Gastonia, NC 28054. Phone: (704) 825-5341 or (704) 827-5538.

September
Mars Star Parties and Lectures. Sponsored by the Edmonton Space Sciences Centre, Edmonton, Alberta. Events held throughout the month. Contact: Edmonton Space Sciences Centre, 11211-142 Street, Edmonton, Alberta, Canada T5M 4A1. Phone: (403) 452-9100.

September
Mars Program and Star Party, Cernan Earth and Space Center, River Grove, Illinois. Events held throughout the month. Contact: Bart Benjamin, Cernan Earth and Space Center, Triton College, 2000 Fifth Avenue, River Grove, IL 60171. Phone: (312) 456-5886.

September
Mars Watch Star Parties, Patterson Planetarium, Columbus, Georgia. Events held throughout the month. Contact: Carole Rutland Groce, Patterson Planetarium, 2900 Woodruff Farm Road, Columbus, GA 31907. Phone: (404) 568-1730.

September 4
Mars Fest '88, South Holland, Illinois. Sponsored by the Planetary Society of Chicago and Thornton Community College. Contact: The Planetary Society, 65 North Catalina Avenue, Pasadena, CA 91106. Phone: (818) 793-5100.

September 9-10
Northern Virginia Telescope Meet. Contact: Scott Huggins, 6028 Ticonderoga Court, Burke, VA 22015-3356. Phone: (703) 256-4430.

September 9-11
9th Annual Astrofest, Camp Shaw-Waw-Nas-See, sixty miles south of Chicago. Sponsored by the Chicago Astronomical Society. Contact: Astrofest, P.O. Box 596-A, Tinley Park, IL 60477.

September 10
4th Annual All-Night Blue Ridge Parkway Regional Stargaze, Part I, Julian Price Park, Blowing Rock, North Carolina. Sponsored by the Catawba Valley Astronomy Club. Part II will be held at the same location on October 15. Contact: Greg Kirby, 12 East Street, Granite Falls, NC 28630. Phone: (704) 396-7656.

September 10
Starconn II, Wesleyan University, Middletown, Connecticut. Contact: Bruce Cole, P.O. Box 93, Simsbury, CT 06070. Phone: (203) 651-8239.

September 16
Mars Mania Star Party, Rifle Camp Park Observatory, West Paterson, New Jersey. Sponsored by the North Jersey Astronomical Group. Phone: (201) 345-STAR.

September 16
Mars Mania Star Party, Roseburg, Oregon. Sponsored by the Umpqua Amateur Astronomers. Contact: Paul D. Morgan, U.A.A. President, 3150 Military Avenue, Roseburg, OR 97470. Phone: (503) 673-1081.

September 16-18
2nd Annual Whirlpool Star Party, historic Birr Castle, County Offaly, Ireland. Contact: Tony O'Hanlon, IAA Secretary, Limerick Astronomy Club, 54 Ballycannon Heights, Meelick, County Clare, Republic of Ireland.

September 16-18
Astronomer's Conjunction, Northfield Environmental Center, Northfield, Massachusetts. Contact: Jack Megas, 311 Surrey Road, Springfield, MA 01118.

September 17
Mars Mania, Cheyenne, Wyoming. Sponsored by the Cheyenne Astronomical Society. Phone (307) 634-2509.

September 17
City Lights Star Show, featuring Mars and Saturn, Claremont, California. Sponsored by the Pomona Valley Amateur Astronomers. Phone: (714) 860-5373 (evenings).

September 17
Mars Seminar, John Deere Planetarium, Augustana College, Rock Island, Illinois. Sponsored by the Popular Astronomy Club, Inc. Displays, planetarium program, Mars observing, and guest speaker William Higgens of the National Space Society. Contact: Paul R. Castle, Popular Astronomy Club, Inc., John Deere Planetarium, Augustana College, Rock Island, IL 61201. Phone: (309) 786-6119.

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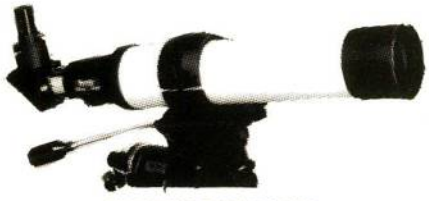

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FOR SALE – Celestron 32mm 1-1/4" Erfle eyepiece. Perfect condition, never used. $45 freight paid. Contact Vince Thaner, 54 Larch Street, Carteret, NJ 07008. Phone (201) 969-2422.

FOR SALE – C11/14 pier, Celestron type, four feet high for latitude 40°, 210 pounds. $450 plus shipping. Contact Paul Signorelli, Las Brisas Observatory, Colorado Springs, CO 80934-6069.

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FOR SALE – Orange Celestron C5 made in 1981, 0.96" diagonal, 12mm Ortho, 25mm Kellner, porro prism, 2.5x Barlow, 1.25" visual back and expansion bushing, tripod, wedge, drive, and manual. $450 includes shipping in the continental U.S. Contact D. Bruce, 623 Stafford, Spartanburg, SC 29302. Phone (803) 582-4988.

FOR SALE – Odyssey I 13.1" telescope with finder scope and eyepiece. $400. Will deliver in two hundred-mile radius. Phone Mike at (608) 783-0699.

FOR SALE – ASTRONOMY. March 1974-February 1977. Excellent condition. $75. Contact L. S. Ormiston, 1001 Cedar Drive, Oxford, OH 45056.

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ANNOUNCEMENT – Stella Della Valley II, a weekend gathering for amateur astronomers, will be held on October 14-16, 1988, at Camp Onas, Ottsville, PA. Activities include dark-sky viewing, lectures, and workshops. Contact Ed Radomski, 36 Far View Road, Chalfont, PA 18914. Phone (215) 822-8312.

Readings and Resources

Sunlike Stars (page 22)
The Life and Death of Stars by Donald Cooke, (Crown Publishers, 1985). High-level popular book on star evolution.

Astronomy Education (page 36)
"The Universe in the Classroom," the Astronomical Society of the Pacific's newsletter on teaching astronomy, is free when requested on school letterhead. Send requests to Teachers' Newsletter Department, 390 Ashton Avenue, San Francisco, CA 94112.

Pluto (page 52)
Out of the Darkness: The Planet Pluto by Clyde W. Tombaugh and Patrick Moore, (Stackpole Books, 1980). The story of Pluto's first fifty years, told in part by Pluto's discoverer.

Copernicus Crater (page 70)
Exploring the Moon through Binoculars and Small Telescopes by Ernest H. Cherrington, Jr., (Dover Publications, 1984). Includes day-by-day descriptions of what you can see with small instruments.

Moon, Mars, and Venus by Antonin Rukl, (Hamlyn, 1976). An excellent pocket-size lunar atlas.

Other famous lunar guidebooks, all titled *The Moon*, were written by Edmund Neison (1876), Thomas Elger (1895), Walter Goodacre (1931), and H. Percy Wilkins and Patrick Moore (1955).

Southern Clusters (page 75)
Astronomical Objects for Southern Telescopes by E. J. Hartung, (Cambridge University Press, 1984). A detailed observing log that describes objects visible from the Southern Hemisphere.

Small Scopes (page 80)
All about Telescopes by Sam Brown, (Edmund Scientific Co., 1975). Tells you how to make small telescopes, finder scopes, and eyepieces from purchased lenses, parts, and common hardware.

Build Your Own Telescope by Richard Berry, (Charles Scribner's Sons, 1985). Contains a clear explanation of how to collimate a telescope and a detailed discussion of eyepieces.

"Building Fun Telescopes for Less than $10" by Robert Monaghan, ASTRONOMY, May 1987. Explains how to scavenge optical parts from old cameras and surplus equipment.

Color Processing (page 84)
"How to Process Color Slides with the KODAK HOBBY-PAC Color Slide Kit," (Eastman Kodak Company, 1984). Instructional booklet included in the E-6 processing kit.

CREDITS

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COMING IN THE OCTOBER 1988 ISSUE OF ASTRONOMY

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SWEEPSTAKES WINNERS!

If you've been wondering who won the prizes in last year's ASTRONOMY sweepstakes — here are the lucky winners: Paul Ashton, of Ridgecrest, California won our $3,000 GRAND PRIZE SHOPPING SPREE. With his winnings Paul purchased from California Telescope Co.: a Meade electric declination motor, an off-axis guider system, an electric focuser and a tube system; from Orion Telescope Center he purchased Orion's tele-extender, their Astronomer's Flashlight, an enhanced light pollution filter and a deluxe metal accessory case; from Adorama he purchased Meade Barlow and Super Plossil eyepieces, plus a TeleVue Plossil eyepiece; from National Camera Exchange he purchased a Meade 2120 LX5 telescope and piggy-back mount; from Kalmbach Publishing Co. he purchased *Sky Atlas 2000.0* and a copy of the *Light-Hearted Astronomer*.

We had three FIRST PRIZE $500 SHOPPING SPREE winners: Kelly Jola of Ogden, Utah; Joan Carr of Buena Park, California; and David Marvin of Waterloo, Ontario. Kelly chose a Meade 660 reflector from Ad-Libs Astronomics. David purchased a TeleVue Oracle 3 refractor from Adorama. And, Joan selected accessories: hypersensitized film from Lumicon, a Meade 4000 Series eyepiece and a LED map light from Adorama; Orion's illuminated reticle eyepiece, off-axis guider body set, sky-glow filter, observer's chair, telecompressor lens, extension tube, rubber eyeguards, and an Explorer Series Orthoscopic eyepiece all from Orion.

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Photographic Performance. Oracle and Genesis are sharp, fast telephoto lenses, terrestrial or astronomical.

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Mountings. Standard photo tripods, or the rugged Tele Vue Panoramic Mount (shown with Oracle), can be used with both scopes for easy traveling. The Equatorial Systems Mount is great for tracking and features a full range of accessories for astrophotography.

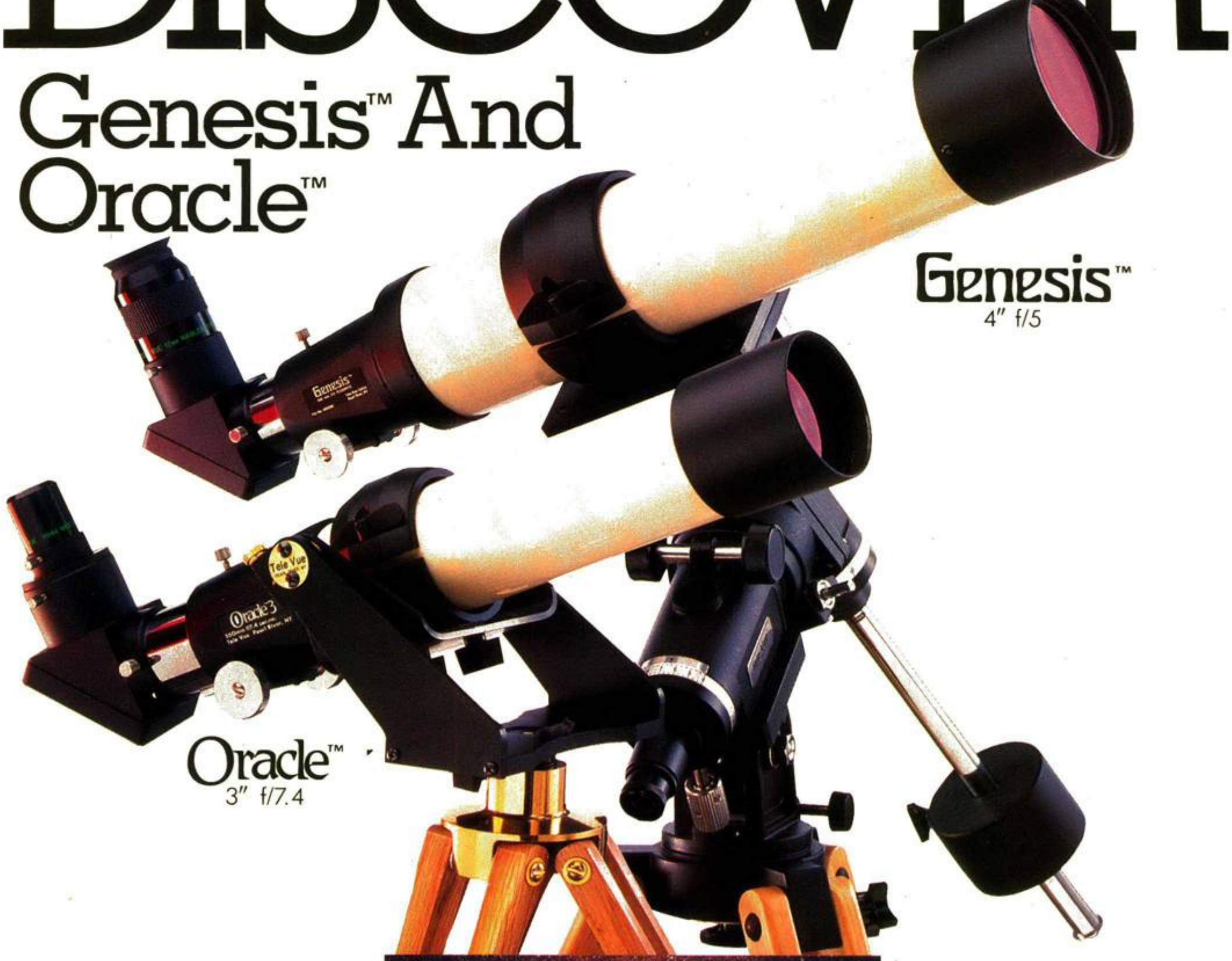
Tele Vue Eyepieces

"Use the best — Tele Vue. After all, the eyepiece is half the telescope," says Dr. Jack Marling. Fast scopes like Genesis and Oracle require the critical sharpness and high contrast of Tele Vue eyepieces. The reduction of astigmatism to improve sharpness across the field is recognized by patents on *all* Tele Vue eyepieces.

Richard Berry, editor of *Astronomy*, called our Plössls "the sharpest I've ever used." Our Wide-Field models represent a significant advance over Erfles, while our

DISCOVER

Genesis™ And Oracle™

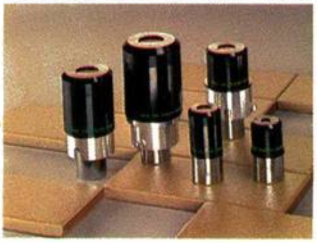


Genesis™
4" f/5

Oracle™
3" f/7.4

Nagler series is considered a landmark breakthrough. Pat Walker called the Naglers "a picture window with magnification." Even today, with fine imitations on the market, critical users will see better edge definition and *larger* apparent fields, regardless of competitive claims.

Tele Vue 50° Plössl, 65° Wide Field, and 82° Nagler eyepieces deliver all the quality inherent in Genesis and Oracle. For maximum performance and power, matched Tele Vue Barlow lenses extend the telescope's focal length 1.8 or 2.5 times. For the widest true field possible, use the 55mm Plössl (with optional new adjustable eyeguard). And consider Nagler Type 2 eyepieces for the ultimate in low and medium power wide-angle viewing, day or night.



Extraordinary Value

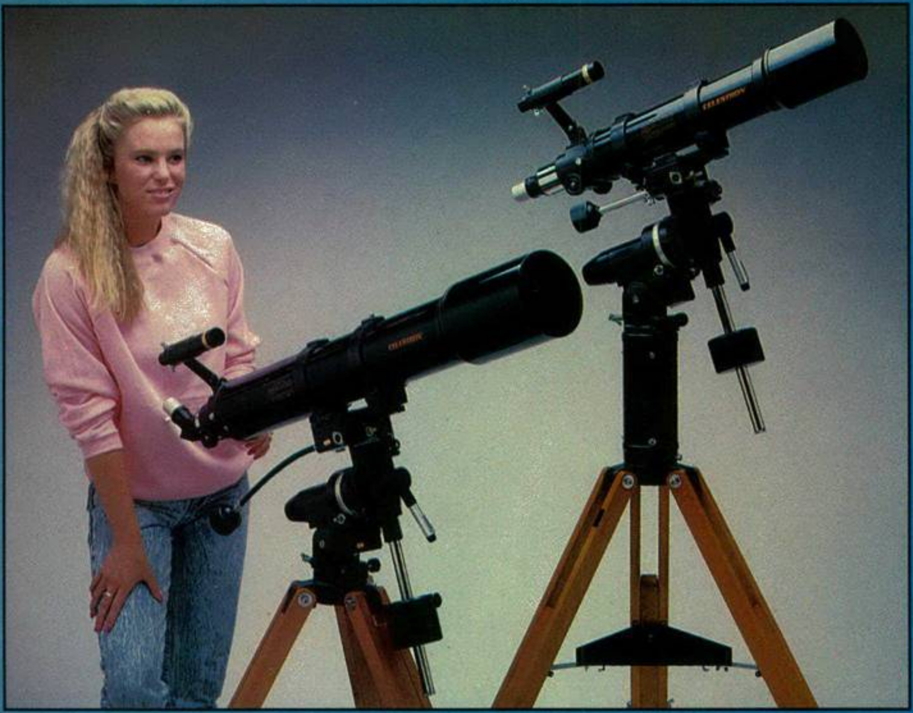
Genesis and Oracle are fully outfitted with these standard features: deluxe case with cutouts for eyepieces, screw-on metal cover and dew shield, 2" rack and pinion focusser with lock screw, 2" mirror-type star diagonal, 1¼" adapter, adjustable mounting ring and a 26mm Plössl.

Whether you're seeking superior sharpness, a more manageable companion to larger instruments, or the finest first telescope, Genesis and Oracle offer no-compromise choices! Send $1 for complete literature package.

Tele Vue™

20 Dexter Plaza, Pearl River, NY 10965
(914) 735-4044

REFRACTORS



Pictured at left is the 102mm, F/8.8 (900mm FL). On the right is the 80mm F/8 (640mm FL) with optional half pier.

THE BEST. . .

ONLY FROM CELESTRON

Celestron has long touted the merits of aperture to prospective buyers. We still do! The saying "there is no substitute for aperture" holds true. (Assuming that the optics are of superb quality.) However, for those discriminating buyers who want a refractor primarily for lunar and planetary work but also want good deep-sky and terrestrial performance, the Celestron multi-coated fluorite apochromat refractors are the ideal choice. The visual and photographic performance of these instruments is incredible.

Fluorite lenses are made of calcium fluoride (a very expensive crystalline material) which provides the ultimate in color correction. Contrary to competitors' claims, fluorite lenses are not fragile, nor affected by moisture or mechanical shock any more than normal lenses.

Celestron fluorite refractors have medium-long focal lengths which easily outperform short focal length refractors of equivalent aperture (94 to 102mm). They also outperform ordinary apochromats due to their very fine color correction, razor sharp pinpoint images, excellent definition and extremely high contrast.

The Celestron fluorite refractors come complete with the Super Polaris German equatorial mount. This deluxe, technically advanced, very sturdy mount utilizes 144-tooth lapped worm gears in both axes. The mount includes a built-in illuminated polar alignment scope. This mount can easily be converted to an alt-azimuth mode for convenient terrestrial usage. A natural wood finish adjustable tripod with accessory tray is included with the instrument. Other standard features include: 1¼" precision focuser, 45° erect image diagonal—1¼", 26mm Plossl ocular—1¼", 6x30 (8°) finderscope and lens shade. The tube length of the 80mm is 22" and the 102mm is 33", respective tube weights are 5½# and 8½#.

Numerous accessories are available to add to your visual and photographic enjoyment—motor drive correctors, focal reducers, t-adapters, tele-extenders, 2" adapters, eyepiece filters, solar filters, half piers, computer operation, digital setting circles and many others.

With thousands of satisfied owners, fluorite refractors continue to gain in popularity. See the best in fluorites . . .only from Celestron. For more information on these units or other fine Celestron products, contact Celestron or your local dealer. Include $2.00 to cover postage and handling.

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